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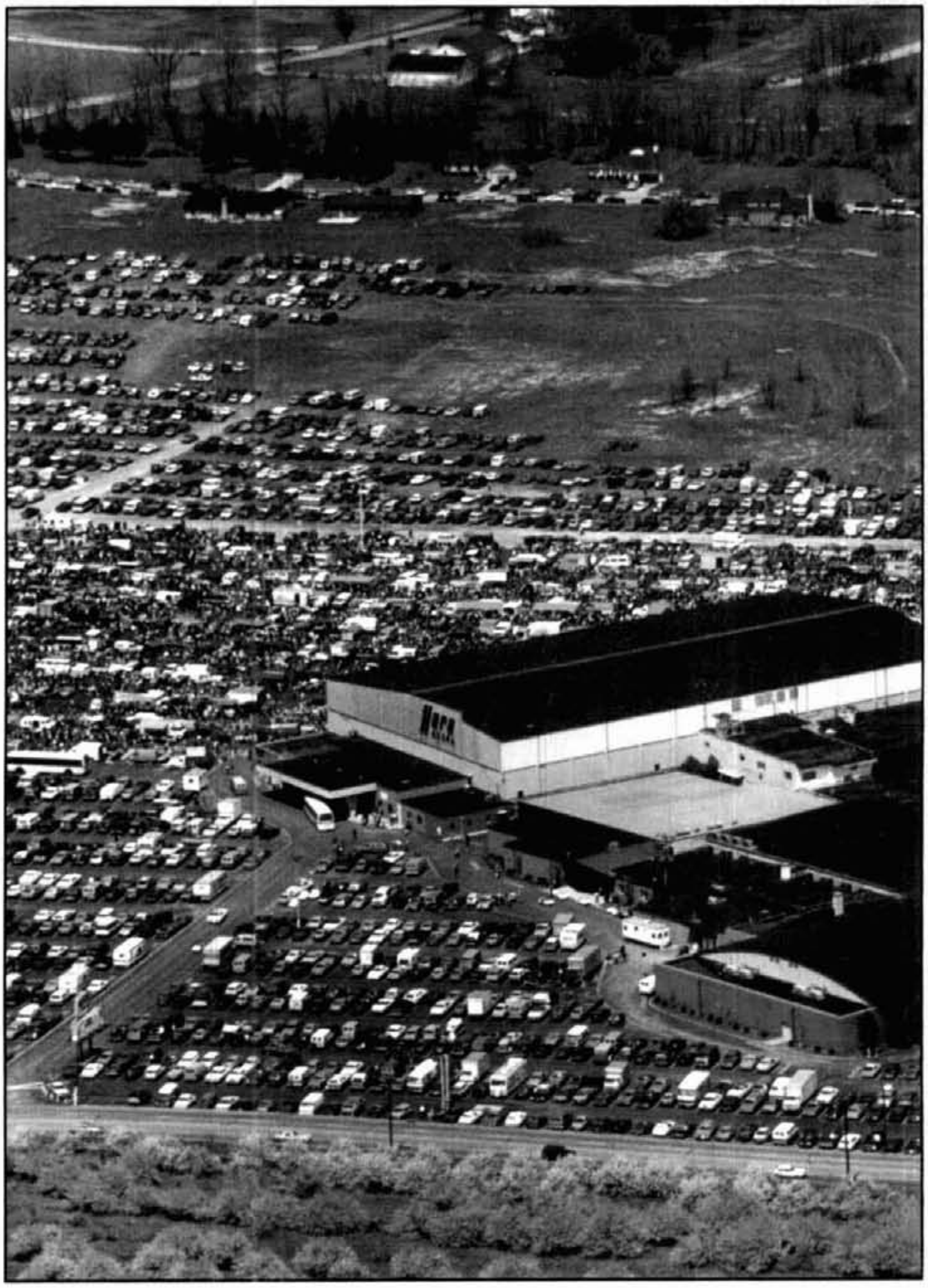

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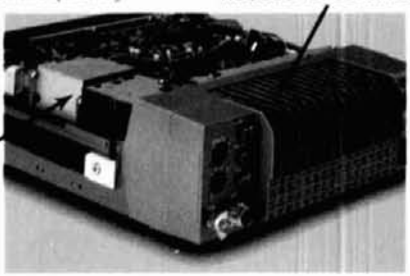


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# ham radio magazine

## APRIL 1988

**volume 21, number 4**

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# contents

# publisher's log

If you take a careful look at our masthead this month you will see that we are in the middle of several changes that deserve a bit of explanation.

You will find that Rich Rosen, K2RR, has left to pursue other activities in the industry. This will give him an opportunity to capitalize on many of the wonderful skills that he has shared with us over the past five years. He has done a superb job at Ham Radio, and he will be missed. However, his new activities offer important opportunities, so we thank him very much for his contributions here and wish him the best of luck as he goes ahead with the next step in his career. He may also have a bit of extra time to get on the air so all of you 75-meter DX'ers had better watch out.

Much of the responsibility of upholding the high standards of the magazine will now fall on the shoulders of Marty Durham, NB1H, who has joined us as technical editor. He brings a variety of rf experience at two defense electronic companies along with a love of contesting and Amateur tinkering and experimentation.

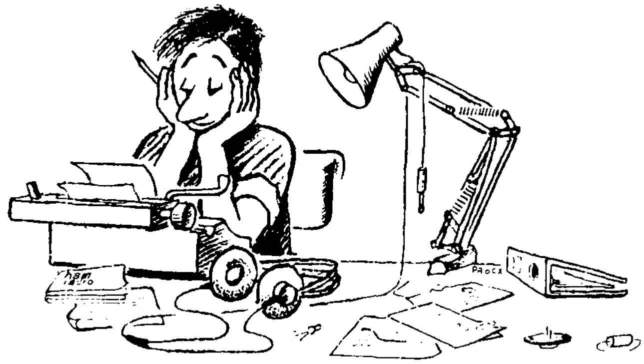
A second well-qualified person who has agreed to help us out is Bob Wilson, WA1TKH, who will be a consulting editor. After he retired from a successful career with a large Boston-area electronics company. Bob and his wife Kit, WA1WQM, co-owned and operated Radiokit for a number of years. As you may know, this firm supplies parts and kits to Amateurs. This experience makes Bob uniquely qualified to advise us as we try to please all of you who like the smell of hot solder.

Finally, to round out another important part of our organization, Henry Gallup has joined us as advertising sales manager. He will be working with Rally Dennis to see that your magazine stays thick and healthy. More ads mean more pages of good articles; so lets all wish him good luck!

Another major change on our masthead is the promotion of Terry Northup to Managing Editor of Ham Radio Magazine. In the few short months Terry has been with us she has proven herself as a most worthy candidate for her new job. She has done a superb job of picking up the many scattered pieces that must go together each month to put out a publication like ours and has done all of this in a most professional way. She has a number of great ideas for the months ahead, and I feel sure that you will find Ham Radio more readable than ever as the magazine responds to her touch.

To round things out, I will reassume the Editor-in Chief's chair, an assignment that should be an easy one considering all the excellent help I'll be getting from Terry, Marty, and Bob along with our topnotch staff including Sue Shorrock, Beth McCormack, and Peggy Tenney.

**Skip Tenney, W1NLB**



# REFLECTIONS

## 500 manuscripts later

**Cedar Rapids presents** many different images for a number of people not least of which is the Collins (Radio) division of Rockwell. To me it represents a beginning. In July, 1982, at the National convention held in Iowa, I joined the staff of Ham Radio magazine as technical editor. Having worked in the publishing industry before (rf design, Microwaves), being an active radio amateur, and an electronics engineer I looked forward to the opportunity of combining my technical skills with that of an avocation that I so dearly enjoyed. I was not to be disappointed.

I really consider myself fortunate. An editor sits in a unique position. I have been privy to so many of your ideas, aspirations, plans. I've seen some great manuscripts, and some that required a little more work. During the past five and a half years we've published some material that, because of the combined practical and theoretical talents of the authors, is unique and just doesn't exist elsewhere — not in the professional journals, nor any of the consumer magazines.

We've received your letters, most of which I've tried to answer — from short notes on the back of a QSL card to major treatises. Ah, then the phone calls. How many hundreds of hours have we spent on the landline together, starting with a germ of an idea only to see it flourish into a full blown concept, and eventually a manuscript, though not necessarily on the same subject. I believe, and probably always will, that some of the most fertile, creative minds belong to our group, the radio Amateurs.

For these opportunities I thank you.

Ham Radio now has a new technical editor and Terry Northup, as Skip just mentioned, has been made managing editor. Continue supporting Ham Radio magazine. Keep sending in those quality manuscripts, keep calling in your suggestions. You have an excellent opportunity as always to help shape the future of this magazine as well as Ham Radio in general.

**Rich Rosen, K2RR**


# comments

## stamps help some hams

**Dear HR:**

We are collecting postage stamps to help finance equipment for disabled Radio Hams throughout the world. Stamps from any country and in any quantity would be very much appreciated. These could include new or old stamps removed from or still on their envelopes.

The project has been running for over a year and has been a tremendous success, with local school children helping with the sorting. All stamps should be sent to my address.

**John Allsopp, G4YDM**
**30 Manor Park, Concord Village, District 11, Washington, Tyne Wear. NE372BT, England**

## international telegraph speed contest

**Dear HR:**

The Blackhawk Chapter of the Morse Telegraph Club has been considering an International Telegraph Speed contest. We would like to run this in conjunction with our Annual Galesburg Railroad Days celebration, generally held on the second weekend of June.

We would like to pattern the contest after criteria used in the 1915 era, awarding medals (probably of pewter or bronze) copied from the original Carnegie Medallion. The contest could apply to both sending and receiving. No bugs would be allowed. There could be separate contests for International and American Morse codes. We would need to charge an entry fee to cover some of the costs — probably $15 to $25.

How much interest is there in such a contest? Because of limited manpower and financial resources, the contest will probably require a special committee under the arm of the international board of the Morse Telegraph Club and/or associated organizations. The Galesburg site provides a fairly central location for both United States and Canadian members and is accessible by rail, bus, and air. We can't think of anything that would be more visible to the public and gain more notice from the media than such an event. Please send your correspondence to me.

**Jim Woods, RR4, Box 22**
**Galesburg, Illinois 61401.**

## renewed friendship

**Dear HR:**

Yesterday I went to the dentist office and was reminded of two old friends. When I went to pick up a magazine I observed *ham radio* among those to choose from. Not only that, but I saw the address label of someone I haven't seen in too many years!

I subscribed to *ham radio* for several years until the cost of *all* the radio magazines got beyond me and I cancelled my subscriptions. I was glad to see this copy and had plenty of time to read it. Thanks to Garson Katona for leaving his *ham radio* in the dentist office. Needless to say, I thought he had a good idea so I left the magazine for the next person.

Thanks and 73. Still good reading.

**Paul Woolverton, W2AEI**
**Trenton, New Jersey 08611**

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- Extended receiver range (138.000-173.995 MHz) on 2 meters; 70 cm coverage is 438.000-449.995 MHz. (Specifications guaranteed on Amateur bands only. Two meter transmit range is 144-148 MHz. Modifiable for MARS/CAP. Permits required.)
- 30 multi-function memory channels. 14 memory channels and one call channel for each band store frequency, repeater offset, CTCSS, and reverse. Channels "A" and "b" establish upper and lower limits for programmable band scan. Channels "C" and "d" store transmit and receive frequencies independently for "odd splits."
- Separate frequency display for "main" and "sub-band."
- 45 Watts on 2 meters, 35 watts on 70 cm. Approx. 5 watts low power.
- Call channel function. A special memory channel for each band stores frequency, offset, and sub-tone of your favorite channel. Simply press the CALL key, and your favorite channel is selected!
- Automatic Band Change (A.B.C.) Automatically changes between main and sub-band when a signal is present.
- Dual watch function allows VHF and UHF receive simultaneously.
- CTCSS encode/decode selectable from front panel or UP/DWN keys on microphone. (Encode built-in, optional TSU-6 needed for decode.)
- Balance control and separate squelch controls for each band.
- Dual antenna ports.
- Full duplex operation.
- Programmable memory and band scanning, with memory channel lock-out and priority watch function.
- Each function key has a unique tone for positive feedback.
- Illuminated front panel controls and keys.
- Dimmer control.
- 16 key DTMF mic. included.
- Handset/remote control option (RC-10).
- Frequency (dial) lock.
- Supplied accessories: 16-key DTMF hand mic., mounting bracket, DC cable.

*Complete service manuals are available for all Kenwood transceivers and most accessories. Specifications, features and prices are subject to change without notice or obligation.*


*TM-721A shown with optional RC-10*

**Optional Accessories:**
• **RC-10** Multi-function handset/remote controller • **PS-430** Power supply • **TSU-6** CTCSS decode unit • **SW-100B** Compact SWR/power/volt meter • **SW-200B** Deluxe SWR/power meter • **SWT-1** 2m antenna tuner • **SWT-2** 70 cm antenna tuner • **SP-40** Compact mobile speaker • **SP-50B** Deluxe mobile speaker • **PG-2N** DC cable • **PG-3B** DC line noise filter • **MC-60A, MC-80, MC-85** Base station mics. • **MA-4000** Dual band mobile antenna (mount not supplied) • **MB-11** Mobile bracket • **MC-43S** UP/DWN hand mic. • **MC-48B** 16-key DTMF hand mic.

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# multi-featured function generator

## Test bench instrument features versatility and low cost

**Any Amateur who enjoys experimenting** knows the frustration of not having the test equipment needed to troubleshoot a problem. I had gradually accumulated most of it, but was still missing an audio function generator. I hadn't planned to build one, but a brief scan of equipment catalogs quickly changed my mind: the equipment had a higher degree of sophistication than I needed and was also expensive.

Function generator projects have been around for years and it's sometimes difficult to find one whose technology falls somewhere between bare basics and high complexity. My requirements for a function generator included: dc offset capability, external frequency measurement, at least one very low frequency range, separate simultaneous outputs, low output impedance, and continuously variable waveshaping. This project is an attempt to fill a niche sometimes neglected in Amateur circles — a simple, versatile, and easily reproduced function generator for someone who needs more than just a simple signal source, but not lab-standard features or performance.

It isn't necessary or even desirable to duplicate this instrument exactly, since each builder may have different operational needs. The circuit is simple enough for anyone with a little experience in junkbox improvisation to reproduce a working model. The total cost, even with all parts purchased new, is about $35.

### features

I chose the XR-2206 monolithic function generator IC as a basic building block; I'd used it before and knew its performance was predictable. I claim no originality for any of the individual circuits presented here — only for the way they're used in my own application. The basic circuit is adapted from the 1985 Radio Shack Semiconductor Reference Guide[1], which is similar to EXAR's data sheets (**fig.1**).

The prototype evolved into its final version over several months. The final design features include:

- Three separate, simultaneous outputs for sine/triangle, square wave, and constant amplitude pulse (for driving a frequency counter, or oscilloscope triggering).
- Usable frequency range from 1 Hz to 100 kHz.
- DC offset, with a momentary spot button to temporarily disable the ac portion of the output signal, so the dc component can be viewed alone on an oscilloscope display or volt-ohm-millimmeter for easy dc offset adjustment.
- Variable amplitude from ≈ 100 millivolts peak-to-peak to ≈ 15 volts peak-to-peak, with switchable attenuation. (The attenuation ratio is about 10:1.)
- Coarse and fine frequency adjustment controls.
- Stable, relatively clean waveforms (although probably not lab standard).
- Continuously variable waveshaping between sine and triangle waves.
- Fairly low output impedance, with almost 5 watts average output power (into 8 ohms).
- Virturally indestructible output circuitry.
- Low cost, easily obtainable components.
- Simple, easy to reproduce circuit.

### dc offset

My first addition to the original circuit was dc offset capability. The logical starting point was at the $R_A$-$R_B$ voltage divider network between $U_1$ pins 3 and 4 (point 1 in **fig. 1**). The voltage at point 1 creates a dc component at the noninverting input, causing a dc component to appear in the output signal at point 2, roughly equal to half the total supply voltage.

In the original XR-2206 circuit, this component in the output provides the required bias for the base of an external amplifier transistor and eliminates the need for a base biasing network. Replacing the $R_A$-$R_B$ divider network with a potentiometer of the same total resistance made the dc offset of $Q_A$'s output theoretically equal to the dc voltage present at the wiper of the pot (minus the base-to-emitter voltage drop). Variable dc offset occurred as the pot was adjusted.

This worked until I tried some routine gain adjustments. A resulting problem was that the resistance of the gain control pot, $R_C$, comprised a small but definite portion of one leg in the voltage divider system

**By Rod Robbins, WA7IRY**, 22435 Bents Road, Aurora, Oregon 97002

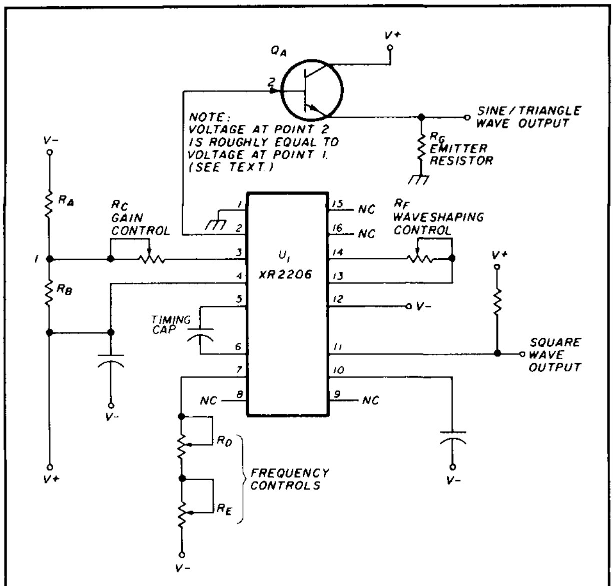


**fig. 1. The original XR-2206 function generator circuit, adapted from the 1985 Radio Shack Semiconductor Reference Guide.**

and whenever the gain was varied, the divider ratio changed slightly, in turn changing the dc offset. This unexpected "feature" meant that the dc offset had to be zeroed each time the gain was changed.

The solution was simple. DC offset can also be achieved in an external base-biasing circuit of output amplifier $Q_3$ (see **fig. 2**). I modified the circuit with a dc blocking capacitor in the IC's output to cut off the small, but annoying, interaction between gain and offset adjustments. I used a surplus 30-k, 10-turn pot as a voltage divider in $Q_3$'s base circuit resulting in a variable base bias voltage as the pot was adjusted (R6 in **fig. 2**). The emitter voltage automatically follows the base voltage, minus the base-to-emitter drop.

While the 10-turn pot provides smooth, high-resolution adjustment, even at high oscilloscope magnification, a standard pot will work. Use one with the smoothest movement and widest adjustment sweep range you can find. Note the circuit now has two dc offset adjustments: a set-and-forget trimpot for initially setting the offset in the original IC circuit, and an oper-

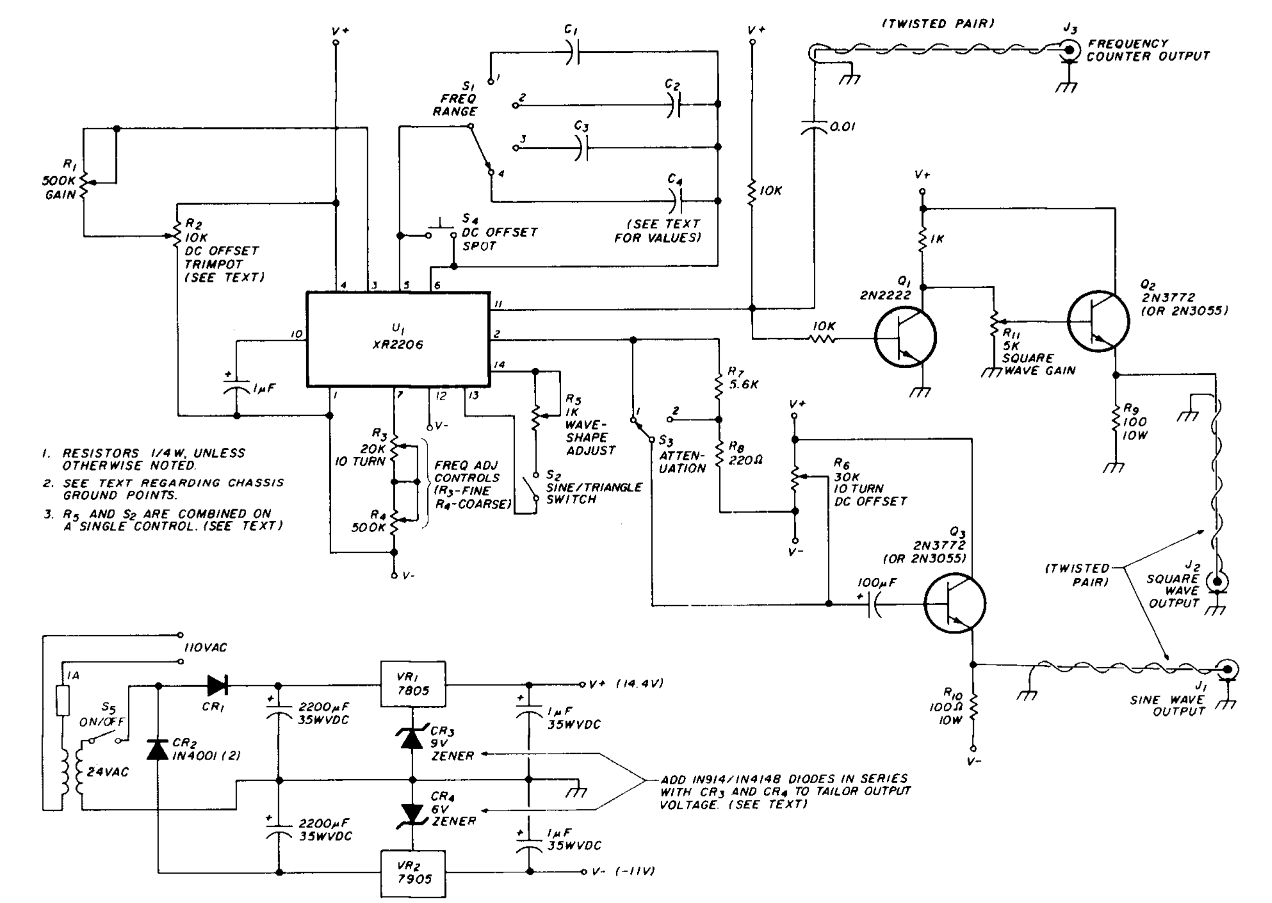


**fig. 2. The final design. Values for the frequency range capacitors, $C_1$-$C_4$, are given in the text. Also, note the diodes inserted in the voltage regulator ground return leads to tailor the output voltages.**

ational control in the output amplifier circuit. (More on this later.)

## frequency adjustment

It's easier and more accurate to read frequency on a counter or oscilloscope. Achieving accuracy and/or linearity on an analog dial face is tough, even for commercial devices.

I added another simultaneous output, $J_3$, producing pulse output for driving a frequency counter or oscilloscope. Even if a counter isn't available, the pulse output frequency can be approximated on an oscilloscope more accurately than on any homebrewed dial face. You can get smooth, high-resolution frequency adjustment by using a pair of good quality pots; one 500 k for coarse adjustment, and one 30-k unit (multiturn if available) for fine adjustments. I used another surplus 10-turn pot of the same type as the dc offset pot. Dial face markings and time-consuming calibration weren't necessary.

## frequency ranges

Frequency ranges are provided by four mechanically switched capacitors. Most homebrew function generator designs I've seen use four or five frequency range capacitors, with values in exact decade steps, to provide (theoretically) a decade step function between ranges. This seldom works in practice, because of variables like component tolerance and stray capacitances in the wiring, switches, and connections.

My design uses external frequency measurement, so I decided that convenience rather than a strict mathematical relationship would determine the bandwidths and range overlaps. Capacitor values determined by experiments allowed me to set up my unit to provide wide, overlapping coverage of portions of the audio spectrum that I needed most. The values are shown in **table 1**.

The range overlaps have no obvious mathematical relationship, nor is the bandspread linear, but this doesn't matter as the frequency is read on external instruments rather than a dial face.

I needed only four ranges, so two positions on the six-position rotary switch are unused. The builder can use as many or as few positions as he wants, as well as different value capacitors to make the ranges.

## switchable attenuation

At this point, the lowest amplitude available from the unmodified circuit was about 800 millivolts peak-to-peak. Because I wanted the option of using the device at lower signal levels, I installed a voltage divider, $R_7$ and $R_8$ (**fig. 2**), in the IC output circuit, just ahead of the blocking capacitor. I experimented to find values that provided about a 10:1 attenuation ratio. They don't mathematically "compute" to this ratio because

**Table 1. Frequency-range capacitors C1-C4**

| Frequency range (hertz) | Capacitance (microfarads) |
|---|---|
| 1-400 | $C_1$ 0.2* |
| 30-5000 | $C_2$ 0.1 |
| 200-10K | $C_3$ 0.01 |
| 8K--100K | $C_4$ 0.00022 |

*$C_1$ actually consists of two 0.1-μF capacitors in parallel.

the input impedance of the emitter follower is involved in the calculation, so it's not really a simple voltage divider relationship. Start out with my attenuation values and change them if you want a different ratio.

When $S_3$ is set at position 2, most of the output voltage is dropped across $R_7$, allowing only the portion of the output signal's amplitude across $R_8$ to be presented to $Q_3$ input. When the switch is in position 1, the entire signal amplitude is dropped across both $R_7$ and $R_8$ and presented to $Q_3$. This provides clean, well-defined signals down to about 100 millivolts peak-to-peak, not bad for a homebrew device.

## waveshaping adjustment

The waveshaping control is a ganged switch potentiometer combination ($R_5$-$S_2$) allowing the waveshape to be varied from a distorted sine wave to a sharp triangle wave as the resistance of $R_5$ increases. At the end of the pot rotation, $S_2$ opens, placing an infinitely high resistance across IC pins 13 and 14, giving the triangle waveform maximum sharpness.

## output amplifiers

This unit uses separate emitter-follower amplifiers for both square and sine/triangle wave outputs, providing adequate power for driving low-impedance loads. Note that according to the Jameco catalog[2] the 2N3772 transistors are rated for a collector current of 30 amps. This seemed like a case of overkill, since the power supply is current limited to 1.5 amps per side. But, while thumbing through parts catalogs for suitable output transistors, I couldn't get past the fact that these monsters are only 89 cents each in single-lot quantities, so I chose the 2N3772. You can use the 2N3055 or similar NPN devices. This type of power transistor is not really necessary but makes the output amplifiers virtually indestructible, at least from the current available from the function generator.

## power supply

I used a split-polarity power supply to enable dc coupling capability. An exact duplication of my power supply isn't necessary — many generic designs have been published. I happened to have an outboard non-

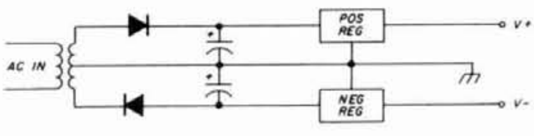


**fig. 3. Block diagram of a generic split-polarity power supply, using a centertapped transformer.**

centertapped transformer, so I used the circuit shown in **fig. 2**. A centertapped junkbox transformer with adequate output voltage would also work. (See the example in **fig. 3**.)

There are a few important considerations whatever power supply design you use. The positive and negative voltages must have enough difference between them to provide adequate voltage swing in the output signal. In my unit, the maximum output amplitude was about 65 percent of the available supply voltage. Don't exceed the XR-2206's maximum rating of 26 volts.

In my design I used 7805- and 7905-series 5-volt positive and negative fixed regulators. I tailored the exact voltage for each side by inserting 1N4148 diodes in the ground return lines, in series with the zener diodes. By hand selecting diodes in the protoboard version of the circuit, I achieved the voltages shown (a total of 25.4 volts between the positive and negative sides). This was measured on a good-quality digital VOM, and was as close as I dared to approach the 26-volt maximum.

Note that I used fixed regulators only because I had them. Adjustable regulators, like the LM317 and LM337 series, can also be used for simple and precise voltage settings.

Another consideration is that the positive voltage should be a few volts higher than the negative. Initially, I made the positive voltage about 0.7 volt higher, to compensate for the base-to-emitter drop in the output amplifier. This made the sine/triangle wave output signal nearly symmetrical as the amplitude reached the clipping level. Because the maximum square-wave output was only +6.5 volts, I readjusted the positive voltage to about 3.4 volts higher than the negative. To gain a higher square-wave output, I had to sacrifice a few volts of sine/triangle wave output. This compromise really isn't necessary if you don't need the higher square-wave output.

## construction

As you can see in **photos A** and **B**, I used simple, straightforward construction methods and a lot of junkbox parts. Most of the circuit is built on an 3-3/8 by 2-7/8 inch Radio Shack "universal pc board" that has solder-ringed holes, two bus lines, and a grounding strip. Parts placement or layout isn't critical. The frequency ranges of the function generator are low enough that stray capacitances and inductances from the board, IC socket, or wiring don't seem to cause any problems.

I built the unit inside a 7-3/4 by 4-3/8 by 2-3/8 inch Radio Shack experimenter box, using the widest plastic side of the box for the faceplate and controls. The removable metal lid became the bottom, was drilled for mounting the two power transistors, and serves as a heat sink. (See **photo C**.) It was not used as an electrical ground plane as such. All chassis ground points on the schematic return to a single tie point on one of the terminal strips. This technique works well in this kind of circuit for eliminating ground loops, oscillation, and instability.

I extended the four bottom rubber feet slightly by inserting small squares of double-faced tape on the bottoms before mounting them to the metal lid.

The ac power transformer was used outboard because there wasn't room inside the cabinet (see in

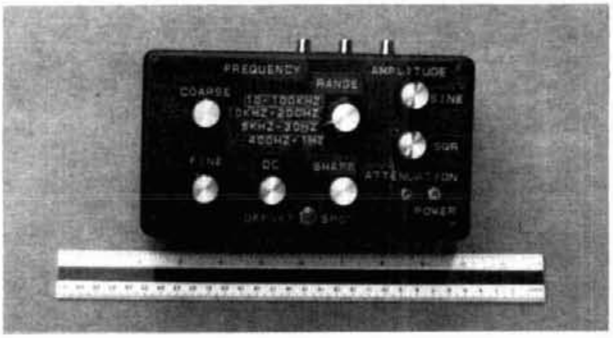

**photo A. Top view of the completed function generator shows panel controls.**

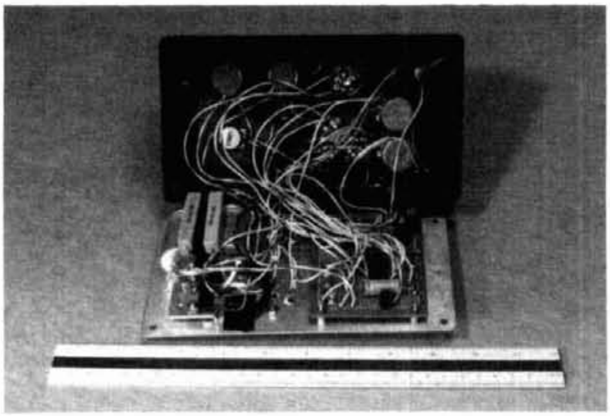

**photo B. Inside view, shows power supply components mounted on the left side of the metal lid, which serves as the bottom. Power resistors $R_9$, $R_{10}$ are located over the electrolytic capacitors.**

photo B). This wasn't a problem in my case because the transformer was designed to be freestanding. I simply removed the cover, took out the unneeded rectifier components, and installed a fuse holder. The transformer's output plugs into the back of the function generator through a mini phone plug and jack.

The layout of the faceplate and output jacks allows enough room between controls for convenient operation without bumping or moving the other settings. I used RCA phono-type output jacks installed on the back of the unit. **Photo D** shows the finished product complete with outboard transformer and a set of homebrew test leads.

## getting the parts

None of the parts for this project are unusual or hard to come by. In the prototype, I tried different pots ranging from 15 k to 50 k for both the dc offset and fine frequency adjustments, with no noticeable difference in results. They don't need to be multiturn types, although they make adjustment smooth and precise.

Whatever you can't find in the junkbox or on flea market tables, you can get at Radio Shack or from the suppliers listed in **table 2**.

## testing and alignment

After the unit is assembled, check the wiring connections against the schematic and inspect for solder bridges and tiny wire strand fragments. When you're sure the wiring is correct, leave the XR-2206 out of its socket, turn on the power, and watch closely. If everything seems right (it's normal for the power resistors, $R_9$ and $R_{10}$, to be quite warm but not smoldering), turn the power off and insert the 2206. Preset the following controls:

1. Frequency range switch $S_1$ to second or third range.
2. Gain (amplitude) control $R_1$ to midrange.
3. XR-2206 dc-offset trimpot $R_2$ to midrange.
4. Frequency adjustment pots $R_3$ and $R_4$ to midrange.
5. Main dc offset pot $R_6$ to midrange.
6. Waveshape adjustment pot $R_5$ to midrange.
7. Square-wave gain pot $R_{11}$ to midrange.
8. Attenuation switch $S_3$ to OFF (Position 1).

Connect an oscilloscope to the sine/triangle wave output, and turn on the power. Hold the dc offset spot button in, and adjust main dc-offset pot $R_6$ to verify that the dc level varies to the expected positive and negative levels. Remember, it's normal for the positive limit to be a few volts higher than the negative. If this checks out, center $R_6$ to 0 volts, and release the spot button.

At this point, a signal of some type should appear on the oscilloscope. The exact shape or frequency isn't important; simply adjust the frequency ranges on the oscilloscope and/or function generator to display two or three complete cycles of whatever waveform you see, and reduce the gain to just below the clipping level.

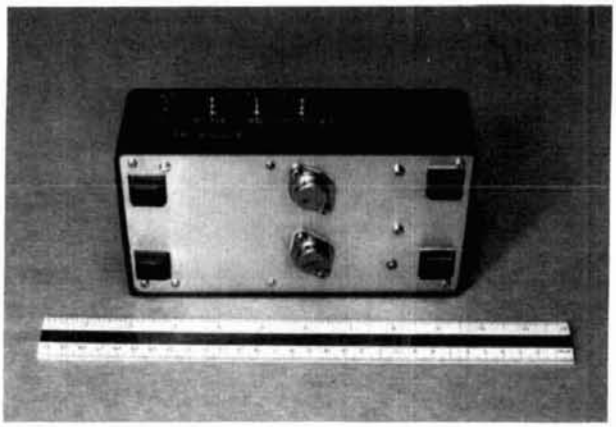

**photo C. Mounting arrangement for the power transistors and rubber feet on the metal lid, which serves as the bottom of the function generator. Along the top edge are the three RC phone jacks for the (left to right) sine/triangle, square wave, and frequency counter outputs, respectively. The 1/8th inch phone jack at the far left is the ac input jack from the outboard transformer.**

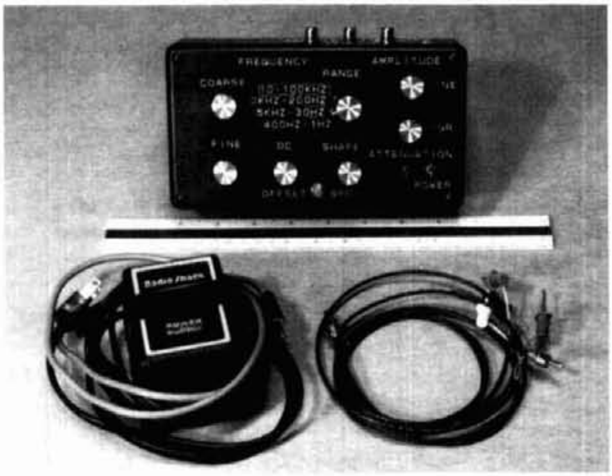


**photo D. The completed unit, shown with the outboard power transformer and set of homebrew test leads.**

Slowly increase the gain until the waveform clips slightly, on either the positive or negative peak. Adjust IC dc-offset trimpot $R_2$ until the waveform drops below the clipping level. Repeat these two steps until the waveform is centered between the positive and negative clipping points. The trimpot is set properly when the waveform clips on both positive and negative peaks at the same time, just as gain reaches the clipping point. Note that this is a set-and-forget control; dc-offset adjustments during normal operation will be done with $R_6$.

Now adjust the waveshape control, the $R_5$-$S_2$ combination, through its entire range, and verify that the

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**Table 2. Suggested parts suppliers**

**Jameco Electronics**, 1355 Shoreway Boulevard, Belmont, California 94002

1. 2N2222A npn general-purpose transistor, 3/$1.00*
2. 2N3772 npn power transistors, $0.89 each (two required).
3. 7805 5-volt positive voltage regulator, TO-220, $0.49.*
4. 7905 5-volt negative voltage regulator, TO-220, $0.59.*
5. LM317T adjustable positive voltage regulator (alternative to no. 3), $0.79.*
6. LM337T adjustable negative voltage regulator (alternative to no. 4), $0.99.
7. XR-2206 monolithic function generator chip, $3.95 each.
8. 2200 $\mu$F electrolytic capacitor, 25 working volts dc, $1.25 each (two required).*

**Radio Shack**

1. Six-position rotary switch, catalog no. 275-1386 (only four positions used), $1.19.
2. Plastic experimenter box, 7-3/4 by 4-3/8 by 2-3/8 inches, catalog no. 270-232, $2.99.
3. Universal PC board, 3-3/8 by 2-7/8 inches, catalog no. 276-168, $1.95.
4. 100-ohm, 10-watt power resistors, catalog no. 271-135 (two required), 2/$0.89.

Miscellaneous parts such as resistors, capacitors, wire, hardware, and knobs may be purchased locally.

*Indicates that these parts may also be purchased at Radio Shack.

waveform varies from a "fat" sine wave to a sharp triangle wave, and all points in between. When the control's rotation reaches the point of opening $S_2$, the waveform should be a very sharp triangle. If the wave shape changes abruptly from a sine wave to a triangle, then the leads to $R_5$ are reversed.

Switch the attenuation in and out at various amplitudes with $S_3$, and verify that the signal is attenuated to about one-tenth its normal strength. (Change the value of $R_8$ for the attenuation you want.)

Connect the oscilloscope to the square-wave output. Vary the square-wave gain control, $R_{11}$ and make sure the output is adjustable from 0 volts to between 60 and 70 percent of $V+$. The waveform should have sharp rise times and should not go negative. My unit produced clear, crisp waveforms until the frequency reached well over 50 kHz, the positive-going edges began to curve, and the duty cycle widened. (Some of this may have been capacitance in the oscilloscope probes and cables.)

Finally, connect the oscilloscope to the frequency counter output. You should see a pulse waveform, with a fairly constant amplitude regardless of any other control settings. If a counter is available, connect it temporarily to the sine/triangle or square-wave output and increase the gain until the counter displays a steady count. Then check the displayed frequency against an approximation from the pulse output measured on the oscilloscope.

This completes the alignment and testing procedure. Connect the frequency counter to counter output $J_3$.

## performance

The completed function generator works well for a relatively simple homebrew device. Its output is more than adequate for almost any type of testing or experimentation a ham is likely to do. The specifications for my model are shown in **table 3**. When operating into an 8-ohm load, the undistorted output is about 2.2 volts peak-to-peak, with the dc offset set at 0. By moving the offset to about +4.5 volts, I was able to get almost 6 volts peak-to-peak of undistorted sine wave — plenty of power to make an earsplitting test of any speaker.

The frequency stability was one of the best results. I let the generator run overnight, connected to the frequency counter. The next morning, the frequency had changed exactly 3 Hz — and some of that could have been drift in the counter! The waveforms are very stable, relatively clean, and can be adjusted to almost perfect sine or triangle waves with the waveshaping control. **Photos E, F,** and **G** show the actual triangle, sine and square waveforms, respectively. Only when the frequency approaches 75 kHz do the waveforms begin to show distortion that can't be compensated by waveshaping (a possible defect in the oscilloscope probes).

**Table 3. Performance data maximum output voltage swings (before clipping).**

| | waveforms (all voltages peak-to-peak, frequency = 1 kHz) | | |
|---|---|---|---|
| **loads (ohms)** | **sine (volts)** | **triangle (volts)** | **square (volts)** |
| 50k | 15.0 | 11.0 | 10.2 |
| 500 | 13.8 | 10.8 | 10.1 |
| 50 | 8.4 | 8.4 | 8.9 |
| 8 | 2.1 | 2.0 | 5.2 |

## suggestions for use

The function generator provides a clean, stable audio signal source for most Amateur-level testing operations. **Figure 4** shows a few suggestions for sample circuit connections.

In example A, assuming the device being tested needs a high-impedance source, simply insert a resistor in series with the function generator's output. Because the generator's output impedance is low compared to most high-impedance circuits, the resistor value can be the same as the tested circuit's impedance. This value will probably be high enough to

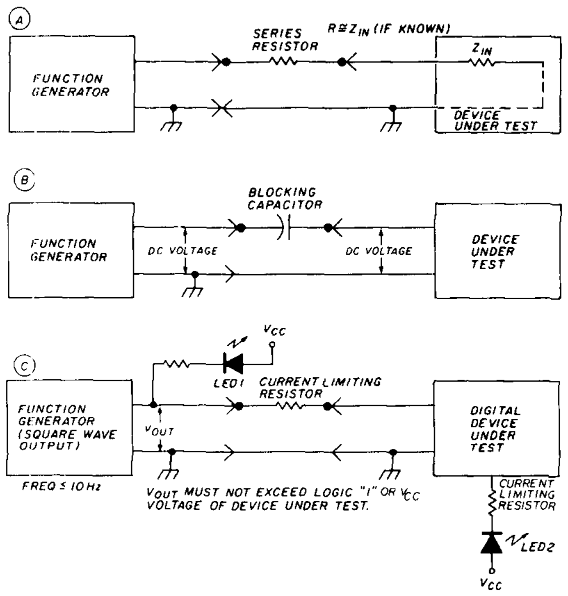


**fig. 4. Suggested circuit connections. (See text for details.) Example A shows using a series resistor to simulate a high-impedance signal source. Example B demonstrates the use of a dc blocking capacitor, to either protect the device under test from inadvertent dc output from the function generator, or to protect the function generator from high dc voltages present in the device under test, such as those found in tube-type equipment. Example C shows the use of current-limiting resistors, to prevent excessive current sinking or sourcing when the square-wave output is used for driving digital devices, as in a clock. Note that an LED can be used to visually monitor the clock speed if it's lower than 10-15 Hz. This also requires a limiting resistor, as shown.**

hide, or swamp out, the function generator's impedance. The series resistor enables the function generator to simulate a high-impedance signal source.

When the dc offset is zeroed, the function generator outputs only ac. However, it's always possible to bump the dc-offset knob, inserting a dc component into the signal. If the circuit you're testing could be damaged by dc, use the blocking capacitor shown in example B. Conversely, if the device to be tested has dc voltages high enough to damage the function generator, use the blocking capacitor to protect it. Be sure the voltage rating of the capacitor is high enough.

Example C shows the square-wave output used with digital devices. The main reason I designed one of the frequency ranges to be as low as 1 Hz was so I could use the generator as a low speed clock for digital prototyping. It's fun to connect a shift register or digital counting circuit of some type, using LEDs to visually monitor the outputs. With a slow speed clock, you can actually watch the device operate. Just make sure the output voltage doesn't exceed the maximum vol-

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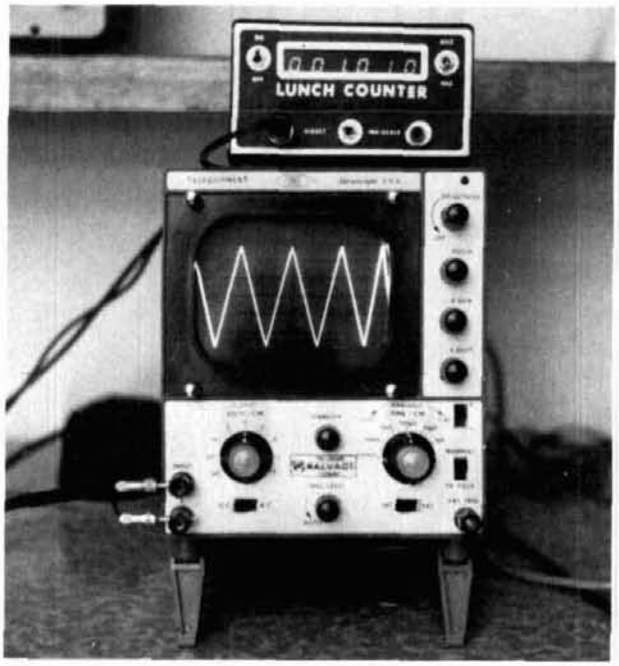


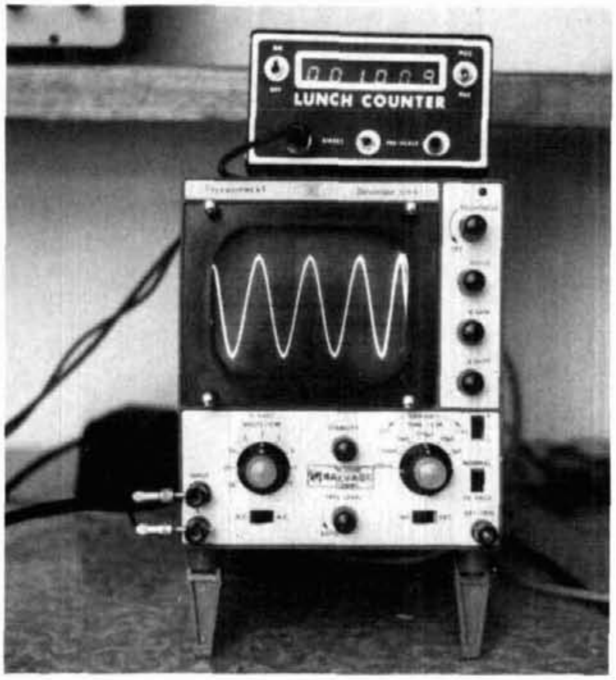




**photo E, F, and G. Oscilloscope displays of the triangle, sine, and square-wave outputs, respectively. The photos were taken at a frequency of about 1 kHz, with amplitudes of about 12 volts peak-to-peak, into a 10-k load. The variable timebase was adjusted to display several cycles for the photos, so the horizontal scale divisions don't correspond to the indicated frequency.**

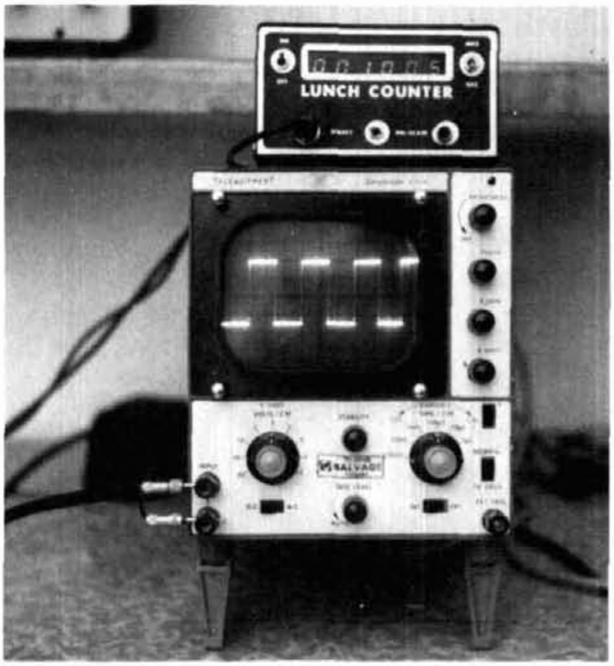
tages required by the chips under test. For example, more than about 5.1 volts will often damage TTLs.

To make the square-wave output positive only, $Q_2$'s emitter resistor is connected to ground, rather than the negative side of the power supply. This means the amplifier output resistance, as seen by the circuit being tested, is only about 100 ohms and problems such as excessive current sinking or sourcing from the external circuit could arise. If this happens, use a series current-limiting resistor in the output.

## conclusion

For a minimum amount of time, money, and junk-box parts, you can construct an inexpensive, versatile test instrument with some of the features found in commercial-grade units. This building-block project uses established, proven circuitry, no exotic parts or techniques, and can be easily assembled by anyone with a little experience. The circuit's performance is tolerant of changes in the prototyping stages, so the builder can improvise, modify, and use materials already on hand.

Anyone who undertakes a project like this can't help learning more about electronics, regardless of his intentions. I now find myself spending more time experimenting because I no longer waste time throwing




together a quick and dirty signal source for testing circuits. It was well worth the effort.

I'll try to help with any problems, and am always interested in hearing about new experimenting techniques, gadgets, and gizmos. Just be sure to include a SASE with any correspondence if you'd like a reply.

## references

1. *1985 Semiconductor Reference Guide*, Radio Shack (Division of Tandy Corporation), 1985.
2. *Jameco Electronics 1987*, Jameco Electronics, Inc., 1987.

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Improving an already fine transceiver

# more operational notes on the TS-930S

**I was gratified to hear** from users of the Kenwood TS-930S who read my earlier article[1] that many operators are interested in improving their SSB transmitted spectral purity, that is, the reduction of Intermodulation Distortion (IMD)*. As a result, I began investigating the radio's characteristics under varying conditions and came up with several modifications.

## SSB linearity

The TS-930S obeys the same principles for linearity (reduced output power and biasing for the most linear region of the devices involved) as other high fidelity, linear systems. Kenwood's Factory Service Bulletin number 867 dated March 29, 1983 notes that the quiescent collector current $I_{CQ}$ of both the drivers and output transistors, MRF-485s and MRF-422s, was increased from 75 mA and 0.5A to 85 mA and 1.0A, respectively. This change made an immediate, audible improvement in the SSB speech quality because the devices were moved closer to their Class A and Class AB1 regions. Biasing the MRF-422s still closer to their Class AB1 region affords even more improvement, most noticeable in the higher order products because bi-polar devices generate more of these products than thermionic devices. Therefore it is necessary to raise the $I_{CQ}$ of the MRF-422s in the power amplifier to a value greater than 1.0A and measure the results with a two-tone generator and spectrum analyzer. By adjusting the bias level potentiometer, VR1, located in the rf shield compartment. The increased device dissipation is easily handled in both the TS-930S and TS-940S because these transistors are operating well below their thermal power dissipation limits. The adjustment is read on the radio's multimeter, and data resulting from changes in the operating parameters is provided in **table 1**. Note that the $I_{CQ}$ of the MRF-485 drivers was not changed; they are already operating well into their most linear region (Class A). Motorola's maximum and typical 3rd order IMs are −36 and −41 dB for the MRF485 and −36 and −39 dB for the MRF422, respectively. Data was taken at 150 watts PEP *per device* at 30 MHz with an $I_{CQ}$ of only 150 mA! Frequency, device matching, and impedance matching affect the results. The TS-930S measurements are intended as guidelines for the reader to improve his transmitter's linearity.

For some contest operators, it is remotely possible that under extreme temperature and humidity conditions a small, quiet, external Whisper™ fan could be used to simultaneously cool the rf and power supply heat sinks. It is also easy to return the power amplifier quiescent collector current to 1.0A for those periods. The test measurement setup is shown in **fig. 1**. All the elements are self-explanatory with the exception of the TS-144/U, a two-tone rf generator whose products are specified to be at least 66 dB down and whose function here is to calibrate and verify the performance of the TS-1379/U. It was designed as a complementary piece of test equipment to the analyzer. In my application in class AB1, the drive requirement is a modest 30 watts PEP. Those using the popular 8877 in Class AB2 should be able to closely duplicate this performance. It should be noted that the TS-930S will easily meet its TX IMD 3rd order performance specifications of less than −31 dB.

A point worth remembering is that quality transistors and tubes, like those supplied by Motorola and Eimac, are specified as exhibiting odd-order IMD products being down so many dB from desired (two) equal tone output signals. This is in accordance with a military standard specification number 1311B-2204B.

*IMD is best defined as "the measured distortion of a linear amplifier as expressed in power in decibels below the amplifier's peak power or below that of one of two tones employed to produce the complex test signal."[2]

By **Marv Gonsior, W6FR**, 418 Adobe Place, Fullerton, California 92635

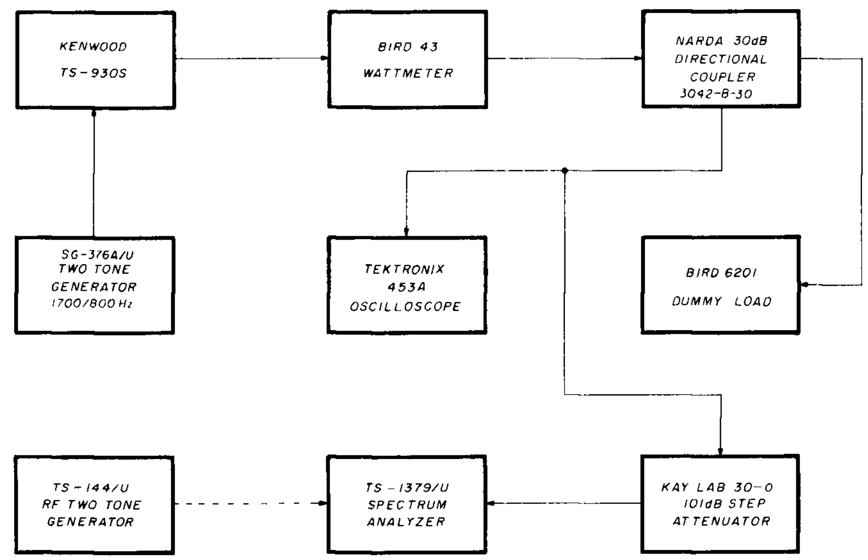


**fig. 1. 50-ohm IMD test set up.**

**Table 1. TS-930S TX IMD data: $I_{CQ}$ versus $P_O$**

Serial Number: 4,010,265
Frequency: 14,175 kHz
Tones: 800 and 1700 Hz
Processor: Off, except as noted.
ALC: Mid-Red Scale (1)
Power Meter: Bird 43

| Icq | 1.0A | | 1.75A | | 2.5A | | (4) 1.0A | (5) 2.5A |
|---|---|---|---|---|---|---|---|---|
| P.E.P. Watts Output | 100 | 50 | 100 | 50 | 100 | 50 | 100 | 25 |
| Distortion Product (2) | | | | | | | | |
| 3 | 36 | 39 | 35 | 38 | 34 | 39 | 20 | 46 |
| 5 | 39 | 42 | 40 | 44 | 40 | 47 | 29 | 48 |
| 7 | 43 | 47 | 44 | 49 | 45 | 55 | 41 | 58 |
| 9 | 47 | 53 | 54 | 60 | 54 | 58 | 43 | 59 |
| 11 | 52 | 56 | 57 | (3) | 58 | (3) | 45 | 60 |
| 13 | 53 | 57 | 59 | (3) | 60 | (3) | 48 | (3) |

Notes:

1. ALC indicated only at the 100-watt level.
2. All distortion product levels are expressed in – dB and referenced to the PEP (see text).
3. Indicates greater than 60 dB.
4. 6 dB average processing and ALC as in (1) above, customary operation by many users.
5. The ultimate linearity employing 0 ALC and compression, with optimum power level.

Amateur radio equipment and many commercial equipment suppliers have chosen a less conservative JEIA/EIA standard which makes the same test, but references the PEP, providing a -6 dB paper improvement in the numbers. Because many Amateurs are accustomed to the latter method, it is used here. Therefore, the tests are the same but the numbers are different. Collins, to my knowledge, specified the IMD in all SSB equipment (both exciters and amplifiers) by the military method of referencing one tone of a pair. A discussion on this subject written by Granberg[2] makes informative reading. Rusgrove's article[3] on the subject of spectrum analysis is also recommended reading for the serious operator.

## don't overlook the amplifier linearity response

We tend to think in terms of exciter IMD performance specifications while missing the fact that it is the overall system which governs final signal quality. In other words, the final amplifier must be more linear to preclude degradation of the driving signal. Good engineering practice dictates that the final amplifier should be 10 dB better than the exciter alone. It is generally accepted that a 3 dB better differential (amplifier with respect to exciter) will result in a 3 dB degradation of the exciter's performance. Therefore, great care must be exercised in the selection and operation of the final amplifier for optimum linearity in a system. Orr published an article on IMD in linear amplifiers with a wealth of information on vacuum tube applications.[4]

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INSIDE VIEW — RS-12A

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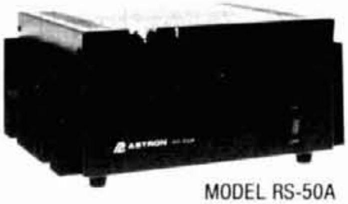
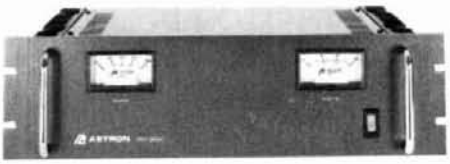


MODEL RS-50A

MODEL RS-50M

MODEL VS-50M

## RM SERIES



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| RM-35A | 25 | 35 | 5¼ × 19 × 12½ | 38 |
| RM-50A | 37 | 50 | 5¼ × 19 × 12½ | 50 |
| • Separate Volt and Amp Meters | | | | |
| RM-12M | 9 | 12 | 5¼ × 19 × 8¼ | 16 |
| RM-35M | 25 | 35 | 5¼ × 19 × 12½ | 38 |
| RM-50M | 37 | 50 | 5¼ × 19 × 12½ | 50 |

## RS-A SERIES

MODEL RS-7A

| MODEL | Continuous Duty (Amps) | ICS* (Amps) | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| RS-3A | 2.5 | 3 | 3 × 4¾ × 5¾ | 4 |
| RS-4A | 3 | 4 | 3¾ × 6½ × 9 | 5 |
| RS-5A | 4 | 5 | 3½ × 6⅛ × 7¼ | 7 |
| RS-7A | 5 | 7 | 3¾ × 6½ × 9 | 9 |
| RS-7B | 5 | 7 | 4 × 7½ × 10¾ | 10 |
| RS-10A | 7.5 | 10 | 4 × 7½ × 10¾ | 11 |
| RS-12A | 9 | 12 | 4½ × 8 × 9 | 13 |
| RS-12B | 9 | 12 | 4 × 7½ × 10¾ | 13 |
| RS-20A | 16 | 20 | 5 × 9 × 10½ | 18 |
| RS-35A | 25 | 35 | 5 × 11 × 11 | 27 |
| RS-50A | 37 | 50 | 6 × 13¾ × 11 | 46 |

## RS-M SERIES

MODEL RS-35M

| MODEL | Continuous Duty (Amps) | ICS* (Amps) | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| • Switchable volt and Amp meter | | | | |
| RS-12M | 9 | 12 | 4½ × 8 × 9 | 13 |
| • Separate volt and Amp meters | | | | |
| RS-20M | 16 | 20 | 5 × 9 × 10½ | 18 |
| RS-35M | 25 | 35 | 5 × 11 × 11 | 27 |
| RS-50M | 37 | 50 | 6 × 13¾ × 11 | 46 |

## VS-M AND VRM-M SERIES

MODEL VS-35M

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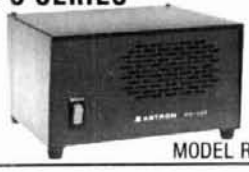
| MODEL | Continuous Duty (Amps) @13.8VDC | @10VDC | @5VDC | ICS* (Amps) @13.8V | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|---|---|
| VS-12M | 9 | 5 | 2 | 12 | 4½ × 8 × 9 | 13 |
| VS-20M | 16 | 9 | 4 | 20 | 5 × 9 × 10½ | 20 |
| VS-35M | 25 | 15 | 7 | 35 | 5 × 11 × 11 | 29 |
| VS-50M | 37 | 22 | 10 | 50 | 6 × 13¾ × 11 | 46 |
| • Variable rack mount power supplies | | | | | | |
| VRM-35M | 25 | 15 | 7 | 35 | 5¼ × 19 × 12½ | 38 |
| VRM-50M | 37 | 22 | 10 | 50 | 5¼ × 19 × 12½ | 50 |

## RS-S SERIES



MODEL RS-12S

- Built in speaker

| MODEL | Continuous Duty (Amps) | ICS* Amps | Size (IN) H × W × D | Shipping Wt. (lbs.) |
|---|---|---|---|---|
| RS-7S | 5 | 7 | 4 × 7½ × 10¾ | 10 |
| RS-10S | 7.5 | 10 | 4 × 7½ × 10¾ | 12 |
| RS-12S | 9 | 12 | 4½ × 8 × 9 | 13 |
| RS-20S | 16 | 20 | 5 × 9 × 10½ | 18 |

*ICS—Intermittent Communication Service (50% Duty Cycle 5min. on 5 min. off)

On this subject, a few caveats are in order. Don't load a linear under single-tone conditions, as optimum power output and linearity will be found only under a complex waveform such as a voice and a two-tone will be only an approximation. Do operate the filament of thoriated tungsten tubes at slightly under the manufacturer's specified voltage for longest tube life and greatest linearity using step start. Measure the filament voltage at the tube socket under load with an accurate voltmeter. It follows that tubes which are being operated under manufacturer's specified parameters will generally last longer and be cleaner than those that are not. There is a strong case for rf negative feedback, though as always, there is a price (which in this case may be in terms of dollars and additional drive required).

## rx single signal reception

Many of us have found that the alignment of the SSB carrier oscillators in the TS-930S and the TS-940S seems slightly high on the slope of the sideband filter. So, when tuning through zero beat of a CW carrier in the sideband mode, the unwanted opposite sideband will be audible. Test for this by enabling the 100-kHz marker signal, tune all the way through it in either the USB or LSB mode, and listen for any carrier on the unwanted side. The remedy (which improves SSB selectivity) is to move the carrier oscillator(s) a little bit further down the slope of the filter while listening until the unwanted sideband disappears. Adjustment(s) for this are TC4 (USB) and TC5 (LSB) located on the Signal Board. (See the service manual for further details and parts locations.) In my radio the two optimum frequencies are 8831.631 and 8828.390 respectively with the slope tuning wide open, as measured on pin 2 of connector 24 using an HP5381A counter. Periodic re-nulling of the balanced modulator is recommended, especially after any carrier oscillator adjustment.

## receiver reciprocal mixing

This well-known phenomenon is common to all receivers incorporating PLL frequency synthesis; the subject has been covered comprehensively by Rohde.[5] Kenwood and others have made improvements in this area for the TS-940S with additional filtering in the PLL circuit. A constructive improvement for the TS-930S was provided by W4CG, and as a result of his work the author simplified that filter into a simple low-pass. It consists of one disc capacitor providing the desired high frequency roll-off and resulting in a 6 dB improvement in the self-generated receiver noise, under conditions stemming from very high level received signals. The filter installation circuit is shown in **fig. 2.** and the test procedure in **table 2.** As in all circuit designs, remember that the buildup of component tolerances

**Table 2. Reciprocal mixing filter test procedure and installation.**

- Enable the 100-kHz marker (14.200 MHz).
- Inject a signal at 14.175 MHz (using any available "clean" generator) and increase its output until the 14.2-MHz marker level at the audio output decreases by 3 dB.
- Turn off the marker generator and notice that reciprocal mixing noise is audible at that frequency and beyond.
- Plug in capacitor C1 and a 6 dB reduction in this noise should occur. (The amount of attenuation is measured at the headphone terminal of the receiver using a Triplett model 630A meter operating in the output, dB scale.) This procedure simulates a strong, close-in signal which is capable of causing the receiver to generate the reciprocal mixing noise. The filter, unfortunately, has no measureable effect on the transmitted signal.

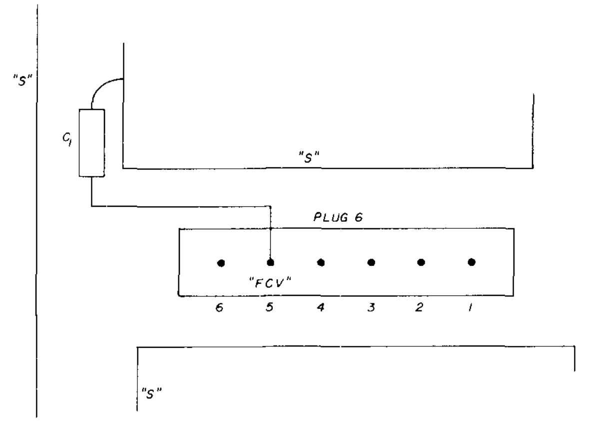



*fig. 2. Filter installation reduces receiver non-reciprocal mixing and loop bandwidth.*

and alignment will be different in each radio. In my TS-930S the installation was effective using a *measured* 0.022 disc capacitor. Because this type of capacitor generally has wide manufacturing tolerances in addition to those inherently in the radio, the capacitor should be measured accurately before installation.

The following test will indicate if the capacitor is correct. With the mod in place, put the transmitter in the QSK mode with a 100-kHz split and keyed at about 45 w.p.m. If the capacitor is too large, a noticeable delay will be found in the PLL seeking to first acquire the alternate frequency, or a slight chirp will be noticed on the leading edge of the CW signal indicating that the loop time is marginally slow. If this is the case, reduce the value of C1 accordingly. A primary concern, with respect to loop filters like this, is that the loop's acquisition time will always degrade with any filtering, and consequently the exact value is a trade-off. In one extreme, the loop time will be so slow that it will fail to function. On-the-air testing of this filter has demonstrated that it will be successful only to the extent that the large signal which generates this type of noise is free of noise sidebands; otherwise, it will be in your passband and nothing will cure it. However, the results of this mod under clean signal conditions have been verified in four other radios.

## automatic antenna tuner

As users of this versatile option have learned, it is a valuable investment from the standpoint of resale and performance because it provides a very effective match from the transmitter to the outside — quite essential in broadband solid-state equipment. The other benefits in using this unit may not be recognized. Second harmonic suppression is increased by a measured 6 dB in my case when it is operating in the "T" match mode occurring from 3 to 14 MHz. Above that, it operates in the ""Pi" configuration which should yield additional attenuation. It prevents automatic shutdown due to a high VSWR, which not only reduces the power output but increases the distortion products since the power amplifier is no longer operating in its most linear mode. The tuner will *not* provide the desireable "flywheel" effect for a Class B GG amplifier since the exciter is generally too electrically remote from the cathode circuit.

## tx audio ac modulation

There are two recognized sources of minor ac modulation of the audio in the TS-930S SSB transmit mode. Both are sometimes elusive but curable. The first is simple magnetic coupling between the dynamic microphone element and the power transformer. To see if this is a problem, move the microphone around the radio (especially on the left side near the power transformer) and listen to the monitor for the results. To minimize the problem, relocate the microphone and use the lowest impedance possible; to eliminate it, change to a nonmagnetic element. The second problem was more elusive and difficult to isolate; W6UYW tracked it down after we spent many hours of searching. It too is audible in the monitor, especially with the microphone disconnected, and must be fixed from the inside. Its source (in serial numbers in the 3.1 to 4.0M range) is a small green rf choke called L3 on page 40 of the Owner's Manual. It is 150 $\mu$H in value installed by Kenwood to eliminate some rf feedback problems being experienced at low frequencies. Unfortunately, this choke is a solenoid type and susceptible to inductive coupling from adjacent cabling. The amount of modulation varies in each unit, depending on its orientation. By reorienting the choke, the modulation can be reduced but not eliminated. For a complete cure, place a drop of solder short it out, or replace it with a ferrite toroidal core or a bead. Find L3 by removing the bottom cover and locating a small pc board directly behind the microphone connector. This choke is not shown on all schematic diagrams. In some cases it is orange or black in color and presents no problem, as it is apparently a closed core, self-shielded design. (The usual warranty caveat applies.)

I hope this information will be useful to operators who wish to improve their transmitted SSB audio quality, and that some of the fixes described will lead to better performance from this fine equipment.

## acknowledgments

I wish to thank W4CG, K5CX, W6UYW, and W0IAK for their contributions.

## references

1. Marv Gonsior, W6FR, ""Simple Modifications and Adjustments for the TS-930S," *ham radio*, April 1987, pages 19-22.
2. Helge Granberg, K7ES, "Measuring the Intermodulation Distortion of Linear Amplifiers," Motorola RF Data Manual, second edition, 1981, pages 3-42/44.
3. Jay B. Rusgrove, W1VD, "Spectrum Analysis — One Picture's Worth a...," *QST*, August 1979, pages 15-21.
4. William I. Orr, W6SAI, "Intermodulation Distortion in Linear Amplifiers," *QST*, September 1963.
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**ham radio**


# HAM RADIO TECHNIQUES

**Bill Orr, W6SAI**

## DX is getting better and better! Here's why!

**DX is better this year than last,** and even that was pretty good. Why this sudden improvement in conditions? Some say it's because the sunspot count is rising. Nonsense! What does the sun have to do with DX, anyway? A lot of DX comes through at night when the sun is sleeping. A study of events in the DX world provides several simple answers to this question.

First of all, the earth is shrinking. Remember Columbus? He took nearly a month to reach the New World. The Blue Ribbon liners crossed the Atlantic in a little over three days in the late "thirties". Now, you can cross the Atlantic in a little over three hours in supersonic transport! Have you ever wondered why gas mileage is getting better and better? Cars travel less distance to get to the same places, that's why. It's obvious that the earth is getting smaller every day.

Second, the ionosphere is leaving. Since radio waves pass through the ionosphere, there must be a lot of friction up there to slow things down. Scientists recently discovered a hole in the ionosphere over the Antarctic — it's leaking into space! Once it's all gone, DX conditions will be fantastic!

Third, Chicken Little said, "The sky is falling!" Obviously if the sky is falling, what's left of the ionosphere is closer to the earth. That makes for less friction and it's easier for radio waves to bounce around between DX stations.

Finally, packaging experts have done their job. While the shipping carton the radio comes in gets bigger and bulkier, the radio inside has shrunk. Just like potato chips. The bag is bigger, but there are fewer chips in the bag. The same thing can be said for candy bars and radio equipment. Today's radios are so small that the electrons can zip around in less time! Thus an S9 signal (all signals are S9 to begin with) is still S9 by the time it wends its way through all those ICs and finally reaches your eardrums!

So that's the way it is. And I don't want to hear any more foolishness from George Jacobs, W3ASK, nattering about sunspots and the ionosphere. You now have the straight information, and don't forget who told you!

## good news for "low-fers"

What's a good antenna for 80 and 160 meter DX? How about a quarter-wave vertical, working against a buried counterpoise consisting of 120 radial wires, each a quarter wave long? A lot of low-fer DXers use an antenna of this type with good results. But laying several thousand feet of buried radial wires has discouraged a lot of hams who dream of owning an effective low-band vertical antenna.

Broadcasters, too, have had second thoughts about this type of antenna, a standard broadcast installation since the mid-twenties. It represented a lot of money literally placed in the ground!

Experiments conducted by Arch Doty, Jr., K8FCU; John Frey, W3ESU; and Harry Mills, K4HU, and described in the 1983 bulletin of the *Radio Club of America* showed that the traditional ground radial system (composed of a number of buried or surface wires) could be equaled or bettered by the use of an elevated ground screen about 6 feet above ground. The screen has 50 or more radials connected at their tips to form a spoked wheel about 0.4 wavelength in diameter. This could be an effective substitute for the buried radials, but it is difficult to install and quite expensive.

The next step in this ongoing investigation took place at the recent broadcast symposium of the Institute of Electrical and Electronic Engineers (IEEE). An evaluation of the performance of four elevated radial elements compared with 120 buried ones was presented by investigators from Ohio State University, Cap Cities ABC, Lawrence Livermore Labs, and the Naval Postgraduate Shool.

*The report concluded that as few as four radials above the ground would provide superior performance over 120 buried radials and that power gain at low angles would be enhanced.*

The experiment was conducted at 1 MHz with an antenna height and radial length of one quarter wavelength. Tests showed that skywave radiation was attenuated and power gain at low angles was enhanced. The same procedure was employed at 3 MHz with "very similar results".

The test model antenna had radials elevated 50 inches above ground, and increasing radial length did not appreciably improve performance. Improvement when going from 4 to 120 radials "was not worth the effort of installing".[1]

The studies generally concluded that performance improvement was good for radiation angles of up to about 20 degrees, but above that the buried radials began to have better power gain. Since most 80 and 160 meter DX operation seems to be at angles of 20 degrees or lower, the above-ground radial installation seems to offer a distinct advantage for the low-fer DXers.

## an inexpensive console for crowded quarters

Operating from a small apartment, motor home, or condominium has its problems. One of the most pressing ones is where to put the ham station! Operating a ham rig from a folding card table isn't much fun.

I recently received a catalog from a large mail-order house, and while browsing through it noticed several "Microwave Oven Carts". These were sturdily constructed, oak-finished carts with a top shelf for the microwave and a shelf underneath for utensils and dishes. Below that was a drawer atop a storage area behind double doors. The carts have casters for easy movement and models are available with different shelf configurations.

The smallest one, called a "Utility Cart", has two shelves and a storage space, while larger carts have more shelves. They look nice enough to be considered furniture and all are modestly priced. You could place a transceiver on the lowest shelf and a linear amplifier on top of the cart where the microwave would go. Or perhaps you might put several VHF rigs on the lower shelf and an antenna rotor and SWR meter on the top. A hundred ideas flashed through my mind as I looked at the carts.

Interested? Most large mail order stores supply these. The ones I saw are from BEST Products Corporation.

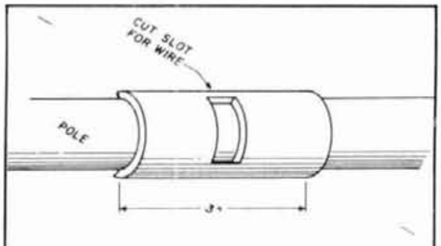


**fig. 1. Short length of PVC plastic pipe is cut to fit over bamboo pole. Tubing is held in place with wire tie-wraps.**


**fig. 2. Wire supports shown in fig. 1** are staggered on Quad arm to distribute wire stress.

## quad antenna construction

Now that 10 meters is coming back to life, there is renewed interest in the Quad antenna. You hear a lot of them on the band these days.

It's not hard to build a Quad, but it is difficult to construct one that will stay up in bad weather. They are floppy affairs at best, and you must put a lot of thought into the physical arrangement of the antenna if you don't want it to come crashing down in the next storm.

Lloyd Hanson, W9YCB, has some interesting ideas on Quad construction. He says the best Quad arms are made of "Calcutta bamboo" with PVC heat-shrink tubing slid over the bamboo between the joints. The end of the arm is also sealed with a short piece of heat shrink. An acceptable alternative for the Quad arm is a fiberglass drapery pole. Lloyd has found a lot of these at garage sales.

The poles should not be drilled for the Quad wires after they've been protected with heat-shrink tubing. Instead, cut a piece of PVC lengthwise to fit the pole. Cut a slot in the tubing to hold the wire and glue it to the Quad arm with PVC cement. Two wire tie-

**SAY YOU SAW IT IN ham radio magazine**

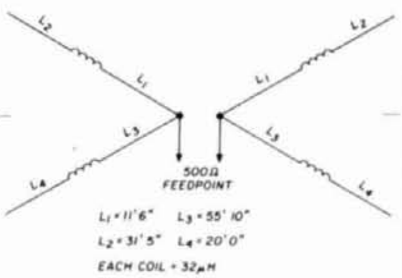


**fig. 3. The Austin-Fourie wideband antenna covers 3.30 MHz with SWR less than 2.5-to-1.**

wraps will hold it securely after the glue has dried (**fig. 1**).

Lloyd staggers the Quad wire supports on each side of the arm to distribute the stress more equally (**fig. 2**). He uses two smaller booms, spaced about one foot apart as supports because a single boom for a four element Quad will not stand the gaff in bad weather.

## a wideband "dipole" antenna

Bill Wildenhein, W8YFB, called my attention to an interesting antenna developed by Dr. Brian Austin and Andre Fourie of the University of Liverpool and described in the September, 1987 issue of *Electronics and Wireless World* published in England. The design functions from 3 to 30 MHz with an SWR of 2.5:1 or less over that range (**fig. 3**).

The antenna consists of two coil-loaded dipoles fed in parallel. A 32-μH loading coil is placed in each dipole half, as shown in the illustration. The angle between the dipoles is not specified.

The feedpoint impedance is about 500 ohms, so the antenna could be fed with a 50-ohm line and a 10:1 balun.

It would be interesting to try this unique antenna in an inverted-V arrangement and run an SWR curve across the operating range. Any takers?

## antennas for the 24.9-MHz band

Need a quick design for a beam antenna for this band? Simply take an applicable 6-meter beam (50 MHz) and multiply all important dimensions by 2!

## references

1. *Radio World*, a publication of Industry Marketing Advisory Services, Inc., 5827 Columbia Pike, Suite 310, Falls Church, Virginia 22041, October 15, 1987.

**ham radio**

# frequency synthesis up to 2 GHz

## Try these ideas for the 23- and 13-cm bands

**Digital frequency synthesis** in the Gigahertz and higher range offers output frequency stability equal to that of the reference crystal and better than that available from dielectric resonator oscillators (DROs). This article describes a simple, low-cost synthesizer built around a Plessey PLL programmable frequency synthesizer IC. The circuit provides a frequency source for use in a variety of applications including a local oscillator and the input for a frequency multiplier. My hope is that the basic circuit will encourage experimentation with more sophisticated frequency loading methods such as from microprocessors or computers.

### circuit description

The heart of the circuit shown in **fig. 1** is the SP5051/DG synthesizer. With a 4.0-MHz reference crystal, the SP5051 synthesizes frequencies between 64 MHz and 2.048 GHz, with a 125-kHz minimum step size. The reference crystal frequency is divided by 64 and then by 16 to provide a 3.90625-kHz reference frequency. The VCO output is applied to a divide-by-32 prescaler with a minimum sensitivity of 100 mV at 2 GHz. The prescaler output is applied to the programmable multi-modulus divide-by-M counter. When the loop is locked, the M counter provides an output which is frequency- and phase-locked to the 3.90625 reference frequency. The pin configuration of the SP5051 is shown in **fig. 2** and a block diagram is shown in **fig. 3**.

The divide ratio is specified using 16-bit serial data entry, where 14 bits drive the programmable M counter and the two most significant bits specify the control select outputs. Data bits are loaded into the storage register on the low-to-high data clock transition only when the chip select input is also high. Chip select should be timed to go high during the low period of the data clock to prevent false data loading. **Figure 4** shows data format and timing requirements. In the circuit shown in **fig. 1**, LEDs are tied to the control outputs to demonstrate their state; in actual practice, these outputs might be used to select alternate band VCOs or to control LNA polarity. **Table 1** shows control select data versus the control output states.

Because the SP5051 is a 5-volt device, an external NPN transistor is driven by the charge pump output, providing the 0- to 30-volt swing necessary to drive the variable capacitance diode in the VCO. During data entry, the charge pump output is disabled by the chip select signal, thereby preventing the generation of spurious output frequencies. The output of the M counter may be monitored at pin 12 at ECL voltage levels if a 6.8-k resistor is connected between pin 12 and ground.

As in the entire SP5000 family of synthesizers, the SP5051 uses mixed ECL and $I^2L$ technologies on the same substrate. Separation of the +5 volt and ground supplies reduces the interaction between circuit sections, but it requires that all supply pins be connected and that both +5 VDC lines be decoupled with quality capacitors near the device itself.

### the VCO

While there are several excellent commercial VCOs available in the desired 1.5- to 2-GHz range (including the Avantek VTO 8150, for example), prices in the $100 area preclude their use in low-cost applications. The design shown in **fig. 1** was developed using BB405 TV tuning diodes (2 pF at 25 volts, 16 pF at 1 volt) and a standard Siemens BFR34A transistor. The cost of both components is just a few dollars.

**By Douglas R. Schmieskors, Jr., WA6DYW,** 4633 Old Ironsides Drive, Suite 250, Santa Clara, California 95054

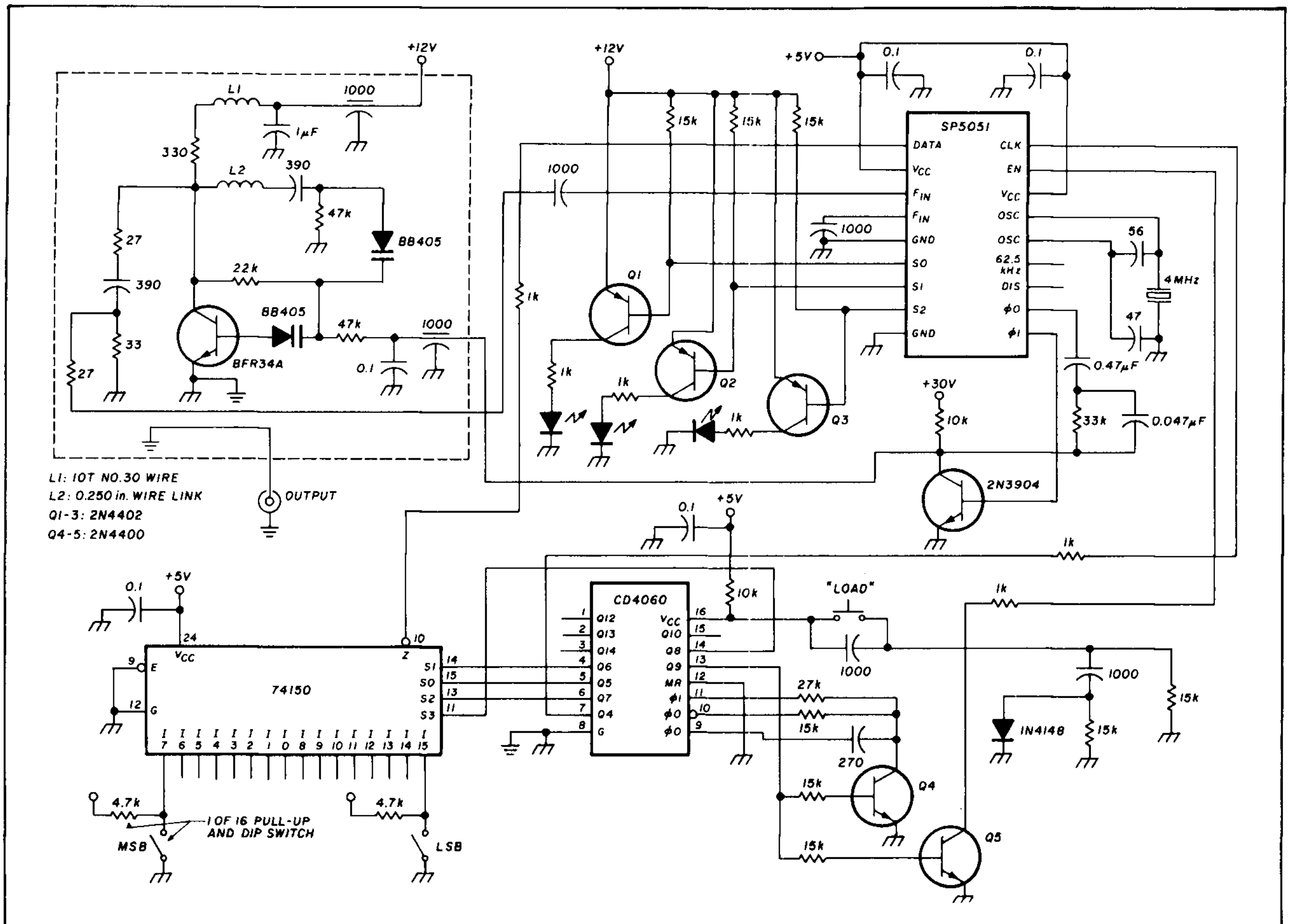


**fig. 1. Demonstration circuit.**

**Table 1. Control select decoding**

| Control select data | | Control outputs pin | | |
|---|---|---|---|---|
| $2^{15}$ | $2^{14}$ | 6 | 7 | 8 |
| 0 | 0 | H | H | H |
| 0 | 1 | H | L | H |
| 1 | 0 | L | H | H |
| 1 | 1 | H | H | L |

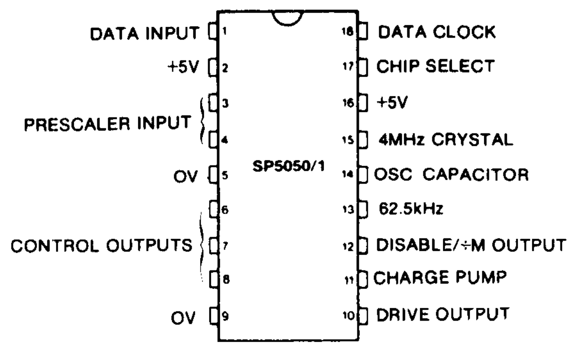


**fig. 2. Pin connections — top view.**

In fixed frequency oscillators, the resonant circuits and decoupling capacitors would be made by using sections of transmission line, but the frequency variation required in this VCO requires the use of conventional components. The series inductance of most capacitors at 2 GHz becomes a major portion of the resonator circuit, and unless care is used in the layout, decoupling is degraded.

The tuning voltage from the 2N3904 is applied through a 47-k resistor to the variable capacitance diodes. These diodes form a series-resonant circuit with the 0.250-inch wire link and the various lead inductances. The 390-pF capacitor provides dc isolation from the collector decoupling, while the 330-ohm resistor also provides some feedback to help stabilize the bias. The 22-k resistor laid directly across the transistor from base to collector sets the bias at about 15 mA, while the emitter is soldered directly to ground to prevent emitter decoupling problems.

Output is coupled from the collector using a 27-ohm

"They said I couldn't work DX with just 100 watts. Especially with a radio that has less than 1000 switches on the front panel.

But the truth is, I'm working lots of DX, more than some of these blockbuster types, thanks to my Yaesu FT-747GX.

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And my FT-747GX is loaded with other features. The receiver works from 100 kHz straight through to 30 MHz, and it's a fantastic shortwave broadcast receiver. I can use all twenty memories for that alone! Plus it's got dual VFOs. A noise blanker. Split frequency operation for the pile-ups. And scanning up the band helps me check out openings as they happen.

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# "They laughed when they saw my radio. Then they saw my logbook."

125

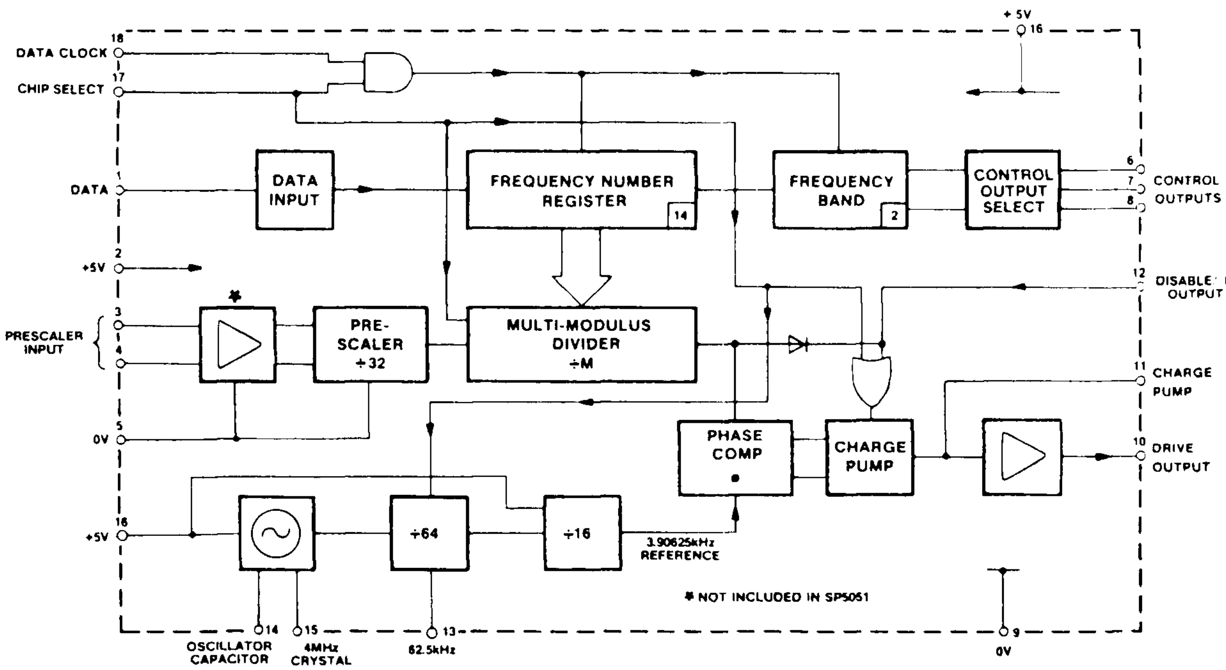


fig. 3. SP5050/1 block diagram.

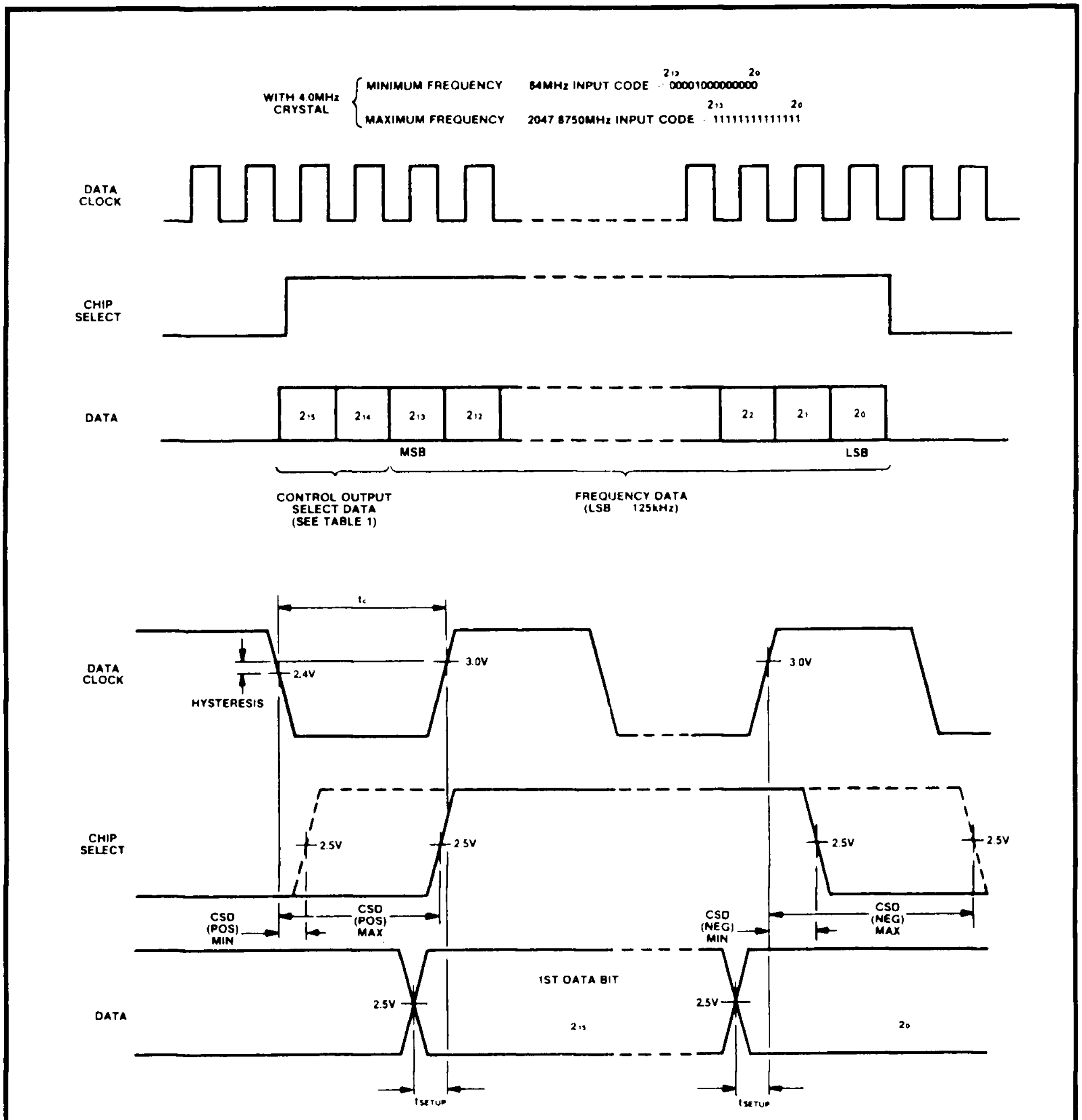


fig. 4. Data format and timing.

resistor and another 390-pF capacitor, while a 33-ohm and a second 27-ohm resistor act as an attenuator prior to the synthesizer input. A coupling link is used to tap off some of the output for connection to a spectrum analyzer or counter.

Standard G10 fiberglass circuit board was used, but board capacitance prevented mounting the resonance-determining components on the board. Teflon™ board would undoubtedly make the oscillator more stable and easier to assemble. Layout with the fiberglass board is critical, and component lead lengths are kept as short as possible by mounting above the board surface.

## operation

In most applications, the SP5051 would be supplied with frequency data by a microprocessor, but because a simple, stand-alone frequency source was desired, an extremely simple and unsophisticated circuit was designed to allow data entry from dip switches. The

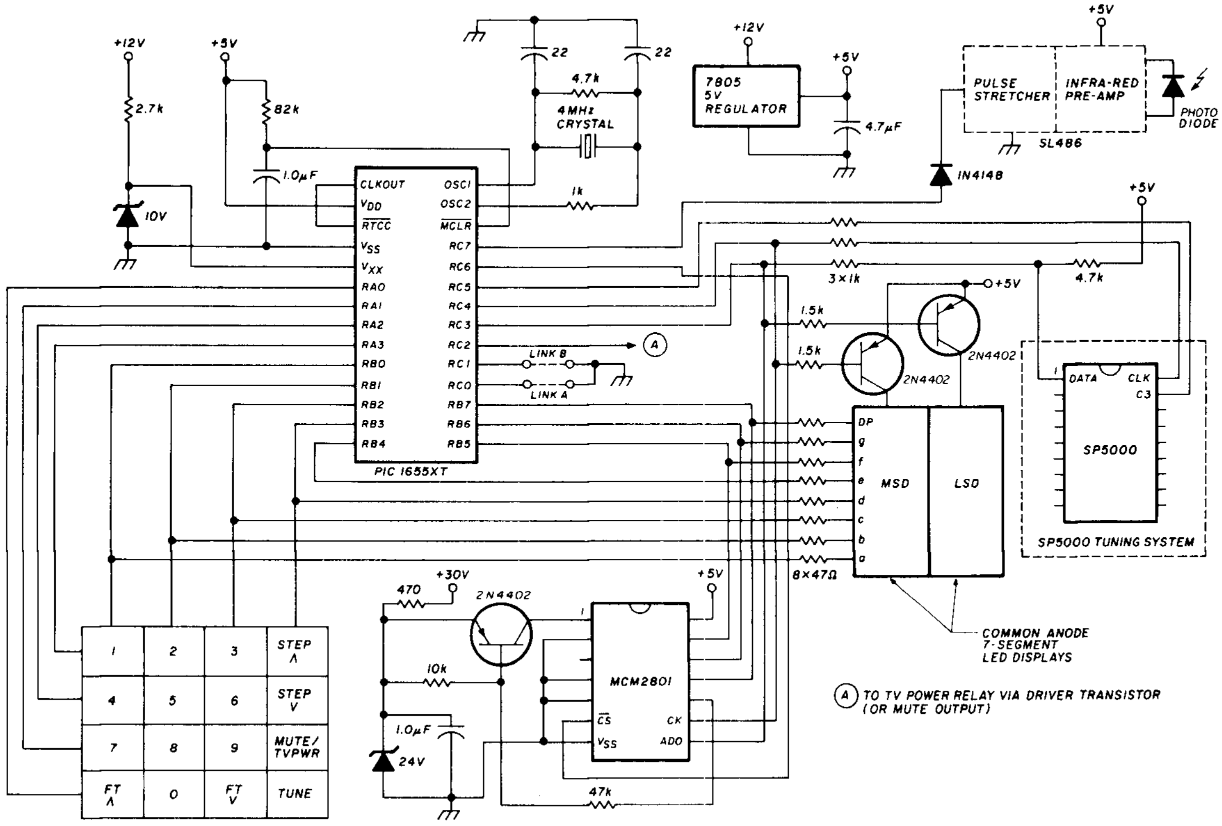


**fig. 5. Demonstration system diagram.**

data clock for the SP5051 is taken from the Q4 output of the CD4060 14-stage counter-oscillator. The 74150 16:1 multiplexer is sequenced by the Q5-Q8 counter outputs and data from the multiplexer output is applied to the SP5051 data input. The Q9 output of the 4060 provides chip select to the SP5051. Closing the push-button switch causes the word programmed by the dip switches to be entered into the SP5051.

## different reference frequencies

The SP5051 is specified to operate with a reference crystal frequency of 2 to 7 MHz. With 200 mV input to the prescaler, the SP5051 has been found to operate to more than 2.5 GHz. To determine a new reference crystal frequency, $f_R$

$$f_R = \frac{f_{MAX}}{512}$$

and

$$f_{STEP} = \frac{f_{MAX}}{2048} \cdot 125$$

where $f_{STEP}$ equals the new minimum step size in kHz and $f_{MAX}$ equals the desired maximum frequency in MHz. Thus, the maximum operating frequency or the minimum step size may be varied within the reference crystal and maximum input frequency ranges of the device.

Another version of the SP5000 family, the SP5060/DG, offers a fixed frequency output of 1.024 GHz based on a 4.0-MHz reference crystal. No data, enable, or clock inputs are required. It can be seen from the formulas above that about 1.8 GHz maximum can be obtained with the SP5060 and a 7-MHz crystal. Other versions of the SP5000 family offer higher input sensitivity, fixed frequency outputs for up-conversion to standard TV channel frequencies, and smaller step sizes.

A very generalized idea for adding microprocessor control, LED frequency display, and remote control to an SP5051-based tuning system is shown in **fig. 5.** The processor drives the LED segments directly, and buffer transistors are used to enable the LED anodes. The desired operating frequency is entered into the processor from either the local or remote keyboard, and the look-up table then provides the correct serial word to the synthesizer.

**ham radio**

# amateur packet radio
## networking and protocols: part 3

### Packet radio protocols past and present

**This is the last** in a three-part series on the inner workings of Amateur packet radio. Part 1 introduced networking and protocols and included a discussion on the OSI/RM (Open Systems Interconnection Reference Model). Part 2 explored the first two layers of the OSI/RM and their applications to Amateur packet radio and examined the AX.25 level 2 packet radio protocol.

Part 3 concludes our look at the second OSI/RM layer with a discussion of other data link layer packet protocols. Also covered are the remaining OSI/RM layers. Special attention is paid to the network layer as current packet radio protocol development centers around networking.

### data link layer

The V-1 protocol, commonly known as the VADCG protocol, was developed in 1979 by Doug Lockhart, VE7APU. That summer, Doug was working on a protocol for the VADCG (Vancouver Amateur Digital Communications Group) TNC (Terminal Node Controller) for use with a master station and multiple TNCs. The TNCs would connect to the station node where they would be assigned numeric addresses, and all communications between users would take place through this node.

A packet group in Hamilton, Ontario was working on developing TNCs and wanted a protocol that allowed the TNCs to be connected to each other directly rather than by way of a station node. Doug was asked if he could provide such a protocol which would free them to experiment with the TNCs and eliminate the need to set up a station node first.

Doug modified the protocol he was using by eliminating dynamic addressing and other facilities employed by the station node. The end result was a simple protocol allowing TNCs to connect directly to each other — a kind of kludge to meet a specific request. This temporary experimental protocol (called the VADCG-1 or V-1 protocol) gained popularity and eventually came to the United States when it was distributed with VADCG TNC kits. Doug has since completed a second VADCG protocol.

Though it was never Doug's intention, the V-1 protocol achieved popularity in the United States and became a packet radio standard because it was the only one around that actually worked.

The VADCG protocol used in the United States was not identical to the one Doug developed for the Hamilton packet operators. The protocol, as it was first used in Canada, allowed for up to 254 numeric addresses and each station would have one assigned beforehand. When Hank Magnuski, KA6M, put the United States' first all-digital simplex packet repeater (now called a digipeater) up in California on December 10, 1980, he used a modified version of the VADCG protocol. A portion of the address space was used to support digipeater control, thus reducing the total number of user addresses from 254 to 32.

The modified version of VADCG protocol used in California became the standard in the United States. Doug was approached several times about making the protocol an international standard, but he consistently resisted this as he saw VADCG as a temporary "testing" protocol too limited for widespread use. These limitations would later cause packet groups in the United States to develop alternate data link level protocols such as AX.25.

**By Jonathan L. Mayo, KR3T**, 3908 Short Hill Drive, Allentown, Pennsylvania 18104

The protocol had only two commands: connect and disconnect. To connect with another station, the user would type his callsign and a CTRL-X. A connect request frame would be sent containing the other station's call, the user's call, and the user's VADCG numeric address. The other station would respond with an acknowledgement including this numeric address and all information frames would then be sent with only the VADCG addresses. To disconnect, the user would type a CTRL-Y and a disconnect request would be sent. Once the disconnect request was acknowledged, the connection was terminated.

The VADCG protocol is still in limited use in Canada and Australia. It is similar to HDLC (High-level Data Link Control) in that numeric addresses are used. Because it is no longer widely used and of limited benefit to most packet operators, a detailed explanation of this protocol is not provided.

## second VADCG protocol "V-2"

Doug Lockhart has continued developing link level protocols because, for various technical reasons, he does not feel that AX.25 is a viable link level protocol for the large scale development of packet radio. His second VADCG protocol, V-2, offers many improvements.

V-2 allows both full and half-duplex links. Multiple links are maintained along with some multiple protocol support. The number of numeric addresses has been significantly increased, and addresses need no initial coordination.

When the second protocol's specifications were published, TAPR (Tucson Amateur Packet Radio) compared them with the AX.25 protocol and found some notable variations but not enough to require changes in the current link level protocol. Some differences are: *reduced address space, differentiation between user names (callsigns) and node addresses (numeric identifier), and no "network level" functions.* V-2 is similar to SLDC, HDLC, AX.25, and V-1. It is designed to be implemented along with upper level protocols to establish a complete network.

## other level 2 protocols

Several data link layer protocols have been used in Amateur packet radio. Two Canadian groups besides the VADCG developed viable packet systems with protocols and TAPR had its own data link layer protocol prior to the adoption of AX.25.

The Montreal group was using a combination COP/BOP (Character Oriented Protocol/Bit Oriented Protocol) with ASCII characters as frame delimiters. This system was operational in 1978 running at 4800 baud AFSK on 220 MHz.

The second Canadian group, based in Ottawa, used a polling protocol and was the first to develop the concept of a digipeater. Their system was running at 9600 baud FSK in 1980.

TAPR had a data link level protocol up and running shortly after their startup. Known as TAPR/DA (TAPR/Dynamic Addressing), this protocol was being implemented before the 1982 AMSAT/AMRAD protocol conference and was one of those considered. It was passed over in favor of AX.25.

## networking

Current work in the United States is directed at level 3 network layer protocols. There are several systems under development today and most are based in level 3 of X.25.

The RATS (Radio Amateur Telecommunications Society) group in New Jersey is experimenting with one system; another is being developed by the FADCA (Florida Amateur Digital Communications Association) group. Right now these systems simply acknowledge packets being repeated through them (replace the end to end ACK of AX.25 with a point to point ACK), but they should soon contain routing tables that will automatically select the best route for a packet to reach its destination, transparently to the user.

Another more recent networking system is NET/ROM developed by Ron Raikes, WA8DED, and Mike Busch, W6IXU. This protocol simply replaces the ROM (Read Only Memory) chip in any TNC-2 compatible TNC (Terminal Node Controller) and makes it a network node. Users can connect to other NET/ROM nodes as well as conventional stations with the benefit of point to point ACKs through the NET/ROM nodes. It also maintains routing tables to other NET/ROM nodes, so it is not necessary to specify a path between nodes.

TAPR's latest project is a *Network Node Controller* (NNC) – a combination hardware and software device designed to serve as a network node in an Amateur packet network. It is actually a small but powerful computer system complete with microprocessor, memory, and external storage. There are four HDLC ports with flexible characteristics.

For instance, two ports might be configured for Bell 202 use on VHF, a third for 9600 baud on UHF, and a fourth for Bell 103 on hf. Thus a user may connect to the NNC on one port and route his packets out one of the others (this may be handled automatically by the NNC's software). The NNC will acknowledge frames as they are received (a point to point acknowledgment).

## network layer sublevels

The network layer (level 3) is usually divided into two distinct sublevels: 3A and 3B. Level 3A is controlled by the INTRAnet protocol and 3B by the

INTERnet protocol. INTRAnet deals with communications around a single network node and user stations while INTERnet takes care of communication between network nodes.

Communications between individual users and their network node (INTRAnet) will probably be through *virtual circuits*. A virtual circuit is a method of connecting stations using an abbreviated address field once a connection is established. The stations must be connected before commmunications can begin, and the addressing information contained in each transmission is decreased after the connection is made. The lack of complete addressing information forces each packet to take the same path through the network.

INTERnet communications are still under debate—they may be virtual circuits or datagrams. A *datagram* is a method of connecting two stations in which each packet sent over the network contains complete addressing information. Their advantage is that they may be dynamically routed through the network (i.e., the path of the connection may change) because they contain complete addressing information. The advantage of virtual circuits is that once the connection is established, the amount of packet space consumed by the address field can be significantly reduced.

Virtual circuits require more reliable, intelligent network nodes to "remember" the path of the connection. Datagrams may reach their destination despite failure of one or more network nodes by being dynamically routed around the nonfunctional ones. Once network nodes are fully implemented, a user from one area of the country can access a node and connect to any other station that the network reaches (similar to the telephone system).

## transport and session layers

OSI/RM Levels 4 and 5 have also been under development for use in Amateur packet radio. A popular contender for the level 4 transport layer is TCP (Transmission Control Protocol). TCP is generally regarded as a complex protocol for dealing with inadequate or unreliable lower layer protocols. TCP also handles the session layer (level 5). Phil Karn, KA9Q, has developed a TCP implementation for packet radio use that can be run on microcomputer systems.

## presentation layer

The presentation layer (level 6) is also getting some attention. The NAPLPS (North American Presentation Level Protocol Syntax) graphics protocol provides a means for graphics transmission via packet radio. Other possibilities are FTP (File Transfer Protocol) and SMTP (Simple Mail Transfer Program).

## application layer

The application layer is the seventh and final OSI/RM level. At this time, there are no true application layer protocols or systems operating or being developed for Amateur packet radio.

## conclusion

To recap, we have finished our discussion of the OSI/RM applications to Amateur packet radio. Keep in mind that the OSI/RM provides an excellent frame of reference for designing a network, but is not cast in stone. Future Amateur packet radio operations might handle high-level protocols differently, but for now appear to be proceeding according to the OSI/RM.

This three part series has covered most aspects of Amateur packet radio networking and protocols. Although some of the concepts may be confusing, in-depth knowledge of networking and protocols is not a prerequisite to operating and enjoying packet radio.

If you have any questions or comments, write to me at the address listed or leave a message on CompuServe; my User ID is 72276,2276.

Portions of this series are from my book, *The Packet Radio Handbook,* available from the *ham radio* Bookstore for $14.95 plus $3.50 shipping and handling.

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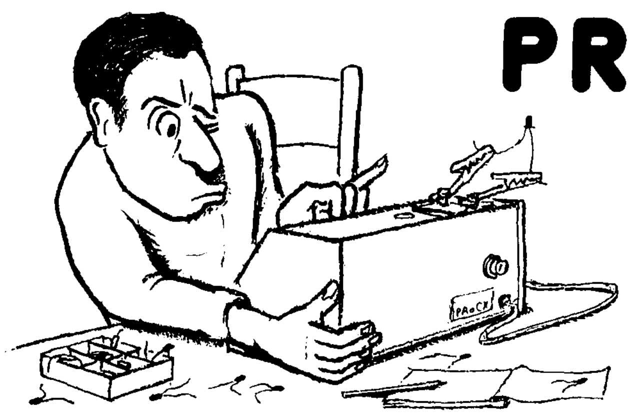

# PRACTICALLY SPEAKING

Joe Carr, K4IPV

## using the digital frequency counter: some pitfalls

**The digital frequency counter** has replaced earlier methods for measuring transmitter frequency. When used correctly, the counter gives nonambiguous readings at the press of a microphone button. Previous methods required operating dials, and, often as not extensive interpolation between dial points using subharmonics of the actual frequency meter reading. As might be expected, accuracy suffered on higher frequencies. When digital counters first made their appearance in the late 1950s and early 1960s they were extremely expensive. The first digital frequency counter that I can recall was a Motorola unit designed for use by their franchised communications shops. Priced at $4,800 the counter would operate only to 500 MHz.

The modern digital frequency counter is based on modern large scale integration (LSI) monolithic chips which make them much cheaper than earlier versions. On my home workbench there is a 600-MHz counter with specifications that make it legal for use in checking Citizen's Band transmitter frequencies (0.005 percent for CB transmitters). The price? At retail I paid $129 and saw it for $30 less (brand new) at hamfests just last year. Expect to pay a bit more for a model with a temperature compensated crystal oscillator (TCXO) in the timebase, but I have seen a 600-MHz TCXO counter for less than $400. Like many electronic products, the performance is about the same as it was 20 years ago, but the price tag is significantly less. Consequently, the digital frequency counter is well within the means of many Amateurs, and should be a part of their workbench test equipment.

Another feature of the little DFC on my bench is its size and weight. Older versions of these instruments were heavy and large. The Motorola was state of the art in its day, but that was another era. It was "portable", but I can attest to the fact that "portable" didn't include carrying it up many flights of stairs to a rooftop repeater site! The 600-MHz counter I now use fits inside a winter coat pocket with space left over. At least three companies sell handheld counters sufficient for most Amateur radio applications.

One problem with digital frequency counters is that erroneous readings can result if they are used improperly. After describing some of the counter's specifications, we will take a look at possible situations where even the best instruments will yield bad readings.

This article assumes you are familiar with the basics of digital counter circuits. A future column will look at various digital counter circuits and schemes, but for now we will deal with the instrument as a "black box", instead of looking at the internal circuitry. We will, however, examine the block diagram of the digital frequency counter.

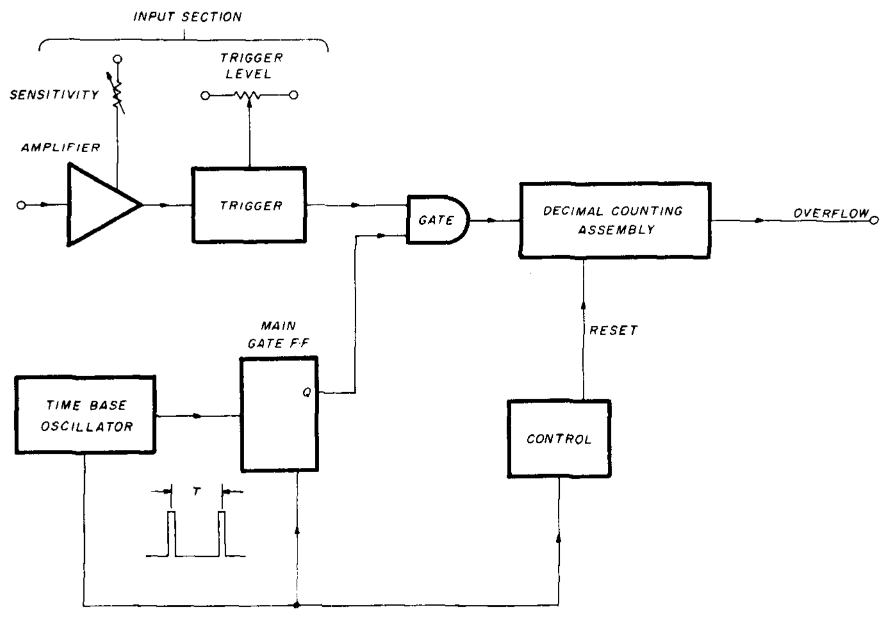


fig. 1. Block diagram of a digital frequency counter.

## digital frequency counters

**Figure 1** shows the block diagram of a typical digital frequency counter. Remember that the definition of frequency is events per unit of time (EPUT). There are five main sections to the counter: Input Section (consisting of the input amplifier and trigger circuit), Main Gate, Decimal Counting Assembly, Timebase, and Control Section.

The *Input Section* acquires the signal and shapes it as needed by the digital circuits. This signal is anything from a simple sine wave to a highly complex waveform with high harmonic content. The input amplifier is designed to boost the level to a point where it can drive the trigger circuit, which shapes the signal into a single binary pulse for each cycle. The counter circuits are binary digital circuits, and will not operate properly when a sine wave or most other waveforms are applied. The trigger circuit is absolutely necessary to the proper functioning of the counter, and it is here that some of the problems occur.

In some UHF and up counters, the input section also contains a frequency divider to reduce the input signal frequency by a preset amount to a range that is compatible with the counter circuits. These stages are common in 1.3-GHz counters. Some dividers are an easy to use 10:1, while others are 2:1 or 5:1 (requiring some mental calculations).

The *Decimal Counting Assembly* (DCA) is the actual counter. Consisting of binary counters connected in divide-by-10 (decimal) configuration, and decoders/numerical displays, the counter increments one count for every input "event". The number of decades (digits) sets the counter's resolution.

The *Control Section* keeps the circuit operating properly. It resets the DCA to zero, and synchronizes the operation of the gating circuit.

The *Timebase Section* sets the "per unit of time" portion of the equation. This circuit produces a periodic output pulse to the *Main Gate* flip-flop, which in turn controls the *Main Gate*. The gate allows pulses into the decimal counter assembly for only a specified period, T. No other section of the frequency counter bears more responsibility for accurate operation under normal conditions than the timebase. Timebase quality is the main difference between lower priced counters and premium "commercial" or "professional" counters.

The timebase section is made up of a crystal-controlled oscillator operated at some frequency (1 MHz, 4 MHz, 10 MHz, etc.) higher than the output pulse rate required. The output of the crystal oscillator is frequency divided down to 10 Hz (0.1-second timebase) or 1 Hz (1-second timebase). When these frequencies are used to control the gate, pulses are allowed into the DCA for either 100 milliseconds or 1 second; the displayed reading is therefore events per 100 milliseconds, or events per second. In general, the frequency of the input signal is:

$$Frequency = \frac{Counts\ on\ DCA}{Time\ (sec)}$$

## trigger circuits

The input signal is rarely a clean square wave at the level required for proper operation of the counter's digital circuits. The signals may be too low in amplitude, or too noisy. The input signal is passed through at least two signal processing stages: an amplifier and a trigger circuit. The amplifier increases the signal from a low level to the 500 to 1000 millivolts typically required to operate the trigger circuits.

The trigger is used to produce a square wave or pulse wave output from a sinusoidal or irregular waveform input signal. The usual trigger stage is the Schmitt trigger. This type of circuit has a built-in hysteresis that is used to shape the waveform. **Figure 2** shows normal operation of the Schmitt trigger on a sinusoidal waveform (operation is similar on non-sine waves). The output of the trigger circuit snaps HIGH when the input signal crosses a preset UPPER LIMIT threshold in a positive going direction,

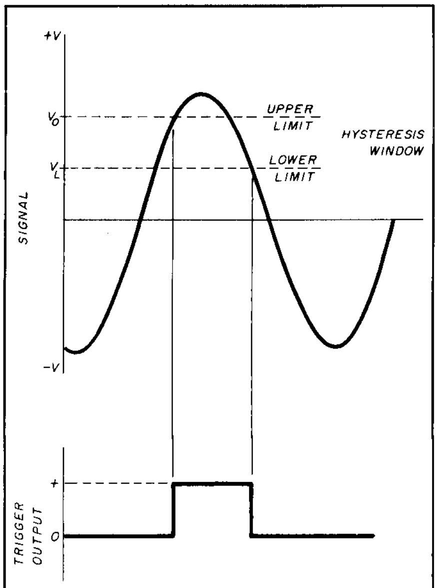


**fig. 2. Properly functioning trigger circuit produces a pulse.**

and remains HIGH until the input signal drops below the lower limit threshold in a negative going direction. The direction of signal change is an important part of the definition for this circuit's operation.

The hysteresis window shown in **fig. 2** is a critical parameter for correct counter operation, and is equal to $V_U$-$V_L$. Incorrect setting of this window can cause erratic or erroneous counter operation. It is a fundamental rule that the input signal must cross both hysteresis limits before a "count" can occur. Some counters have trigger circuit controls allowing the user to position the window and/or set its width.

**Figure 3** shows three conditions in which different settings of the hysteresis window are used. In **fig. 3A** we see a correctly adjusted trigger — both limits are crossed by the input signal, so counting occurs. But in **fig. 3B** the same signal has a dc offset component, the window remains the same, and no counting occurs. This situation occurs especially in low-cost counters that don't allow adjustment of the trigger controls. Finally, we have **fig. 3C** in which the trigger control is set to position the hysteresis window below the signal, again resulting in no counting.


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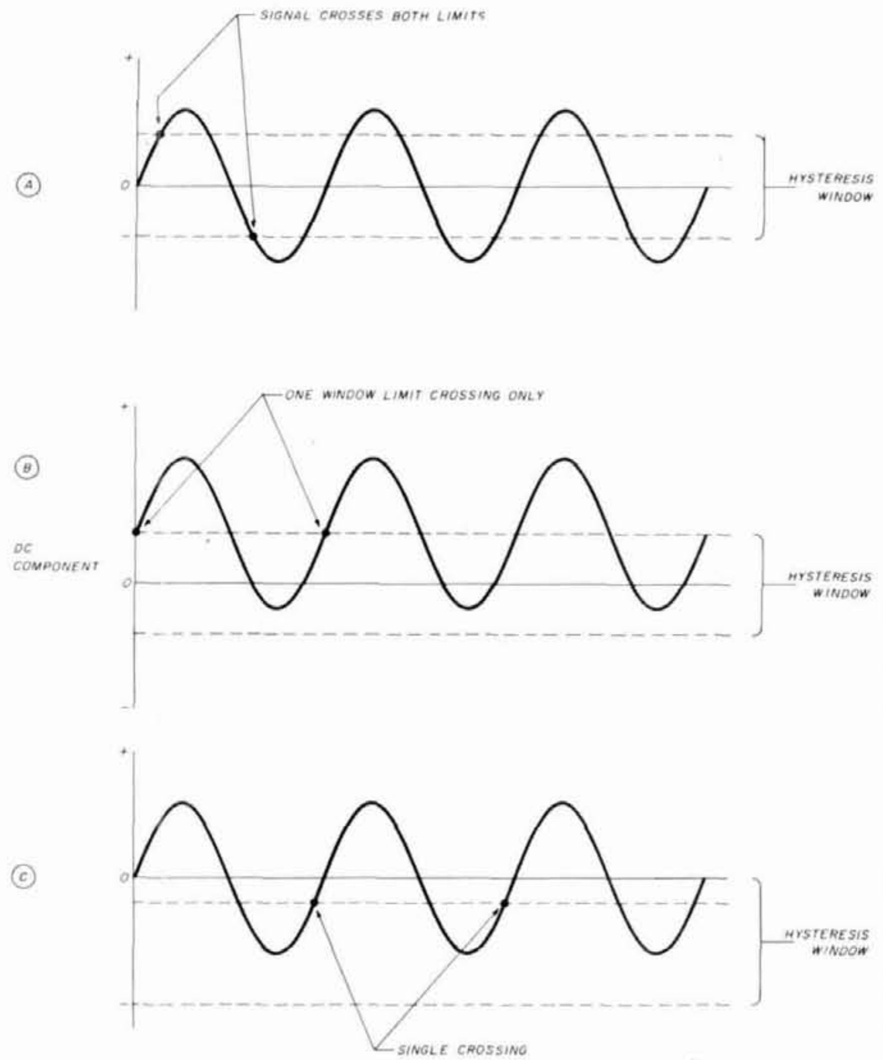


**fig. 3. Several adjustments of trigger control: (A) Proper triggering occurs because signal brackets limits. (B) DC-offset prevents proper crossing of limits, so no count occurs. This situation occurs often in counters with a preset trigger window. (C) Signal only crosses one limit because trigger control is misadjusted.**

Some instruments have a trigger level control allowing the user to adjust the window's position over a continuous range. Some models have a trigger switch that allows selection of three alternatives: Preset (usually centered about 0 baseline), ± (window above 0 baseline), and ± (window below 0 baseline). A *trigger amplitude* control makes it possible to change the window's width (i.e., the value of ($V_U$-$V_L$) in **fig. 2**.

## counter errors

Though several types of errors occur during digital frequency counter operation, they tend to fall into two general categories: inherent and signal related errors. Inherent errors are a function of the quality, age, history, and built-in design factors of the individual counter. Little can be done about them if the counter is poorly designed unless you are willing to spend some money. On the other hand, signal related errors are often correctable, or at least ignorable, through the proper manipulation of input sensitivity, trigger level, and amplitude controls.

Two major sources of inherent error in all frequency counters are: timebase error and one-count ambiguity.

The timebase error is expressed in terms of a percentage, or in parts per million. The error from the timebase inaccuracies is directly reflected in all measurements of frequency and period. For example, suppose a 1.00-MHz timebase is off by 30 Hz and is 1,000,030 Hz instead of 1,000,000 Hz. This is an error of 30 parts per million (30 ppm), which in percent is

$$\frac{(1{,}000{,}030 - 1{,}000{,}000)\,(100\%)}{1{,}000{,}000}$$

$$= 0.003\%$$

The measurement error due to timebase inaccuracy is constant regardless of the frequency being measured. That is, there will be a 0.003 percent error at 1 kHz or 10 MHz. For example, a 21.390-MHz (15 meter) signal would be measured with an error of

$$21.390\ MHz \quad \frac{30\ Hz}{MHz} \quad = 641.7\ Hz$$

This means that a counter reading 21,390,000 would indicate an actual frequency between (21,390,000 − 641.7) = 21,389,358.3 Hz and (21,390,000 + 641.7) = 21,390,641.7 Hz. If the timebase frequency is 30 Hz high, the reading will be low, and if the timebase frequency is 30 Hz low, the reading will be high.

Total timebase inaccuracy is the calibration error that occurs when the timebase is initially adjusted at the factory (or last properly re-calibrated), plus or minus factors like short and long term, temperature, and line voltage stability.

The initial error is directly related to the quality of the laboratory standard used at the factory or metrology laboratory. Proper standards, depending upon the quality of the counter, might be a WWV or WWVH broadcast (not high quality), a 60-kHz WWVB broadcast, or a cesium or rubidium beam standard traceable to the National Bureau of Standards (NBS).

The *short term stability* is the timebase oscillator frequency drift per day, while *long term stability* is the drift rate per month (sometimes called the aging rate). The *temperature change* is the timebase frequency change over a temperature range, usually specified as 0 to 50 degrees C for commercial and Amateur grade counters. The *line voltage change* is the frequency change over a ± 10 percent change in applied line voltage.

Temperature variation can be corrected by using an oven controlled crystal oscillator, or a temperature compensated crystal oscillator (TCXO). The latter is popular and practical for the majority of Amateurs. These changes are probably the most common modifications to improve the operation of low-cost counters. The problem of line voltage change is solved by making certain that the line voltage is regulated. It should be noted that some battery operated counters do exhibit this difficulty. The solution is to use a three-teminal IC voltage regulator to set the power supply voltage for the counter, instead of the internal battery pack.

There are four general classes of timebase used in counters: ac line, room temperature crystal oscillator, temperature controlled crystal oscillator, and oven controlled crystal oscillator. The first of these is found in only the least expensive counters, and incorporates the 60-Hz (50 Hz overseas) ac line frequency as the timebase. The problem is that the "60 Hz" is only marginally accurate over the short term. Although the power company maintains that its frequency is very accurate, that claim is valid only when integrated over a 24-hour period. The 60-Hz referenced counters are useless for measuring transmitter frequencies. The room temperature crystal oscillator is used on many, perhaps most, counters that Amateurs buy and offers only marginal accuracy and stability. The TCXO and oven controlled are best suited for accurate measurements. Although the oven was once the favorite, the TCXO type performs well and is inexpensive.

The *one-count ambiguity* is caused by a lack of synchronization between the input signal and the timebase. In some readings, a single cycle of the input signal may "escape" detection by the decimal counting assembly, so the reading is off by one count in the least significant position. The ± 1 count ambiguity produces an error inversely proportional to the frequency being measured and the gate time:

$$Error\ (\%) = \frac{+/-\ 100\%}{f\,T}$$

Where:

f is the measured frequency in Hertz (Hz)

T is the timebase "gate time", in seconds

EXAMPLE: Find the percentage error due to ±1 count ambiguity of a 2-MHz signal using a gate time of 1 second.

Error (%) = (±100%)/fT

Error (%) = (± 100%)/(2,000,000 Hz)(sec)

Error (%) = 0.0005 percent

The error is ± 1 count no matter what frequency is being measured, so the error decreases for higher frequencies.

The ± 1 count error should not be confused with last digit bobble, seen on some counters, even though the two are related. In this form of error, the least significant digit bounces back and forth between two values because it can't decide which value is correct. This error is seen on most counters, but is especially noticed on counters displaying only the most significant several digits. For example, my counter has a six-digit display, but measures frequency to 600 MHz. If a frequency is 21.390 MHz the reading might be "21390.0." But suppose the actual frequency is 21.389502 MHz? In this case, there is an ambiguity that may translate as a bobble between 21390 and 21389.

Signal related errors are problems (mostly in triggering) caused by poor quality or complex waveform signals. For example, don't even try to measure the frequency of an amplitude modulated or SSBSC signal! Most of these errors result from hysteresis crossing problems, or noise on the signal. Trigger errors occur because the input signal crosses the hysteresis win-

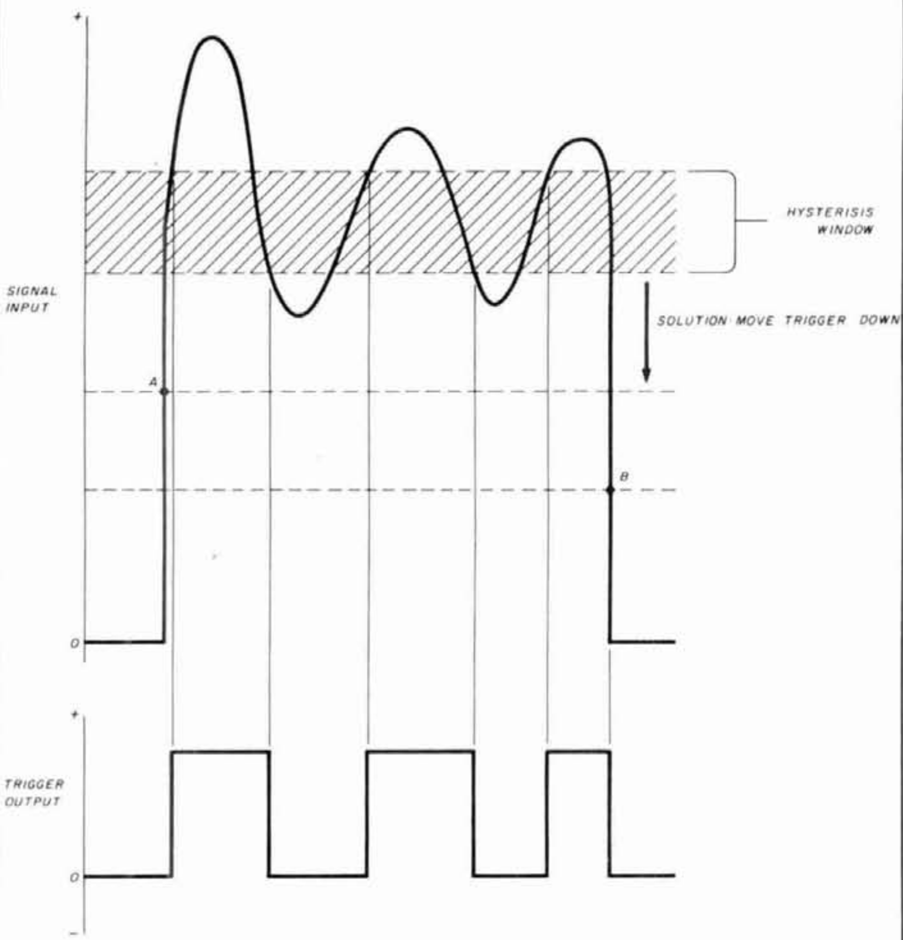


**fig. 4. "Ringing" on pulse causes excessive number of trigger output counts when hysteresis window is positioned in shaded area, but correctly counts when window brackets "A" and "B".**

dow limits either too many (excess counting) or too few (non-counting) times. Recall that the signal must cross the hysteresis limits in both directions on every cycle.

**Figure 4** shows a signal with ringing that tends to amplitude modulate the pulse. If the hysteresis window on the counter is adjusted to the point shown shaded, then the amplitude variations caused by the ringing crosses the limits three times, so the count is of three pulses rather than one. To solve this, adjust the trigger control lower on the pulse so the triggering limits are "A" and "B" as shown.

**Figure 5** shows a sine wave signal with severe harmonic distortion. If the trigger window is adjusted to point "B" then triggering occurs normally,

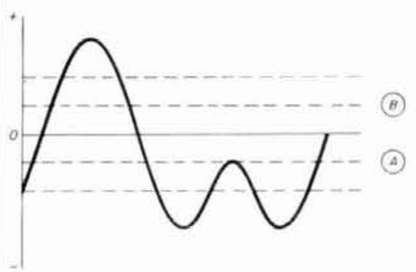


**fig. 5. On distorted sinewave improper triggering occurs at "A" but not at "B". Trigger control should be adjusted to "B".**

and there is no problem. But, if the trigger window is at "A" the counter will double trigger, producing an erroneous count.

In some cases, the sensitivity of the

counter input amplifier is simply too great. In those cases strong signals will drive the input amplifier into distortion and produce some of the problems discussed here. That is why it's a good idea to use a counter with an input sensitivity control, or conversely, an external attenuator if the counter is too sensitive. I plan to present a series of attenuators and pads useful for rf measurements and other applications in a future column.

The material presented here is based in part on *Elements of Electronic Instrumentation & Measurement* by Joe Carr, K4IPV, published by Prentice-Hall/Reston at $23.95. Although out of print, a limited number of hardback copies are available from the author at $15.00 postpaid. Contact J. Carr, POB 1099, Falls Church, Virginia 22041.

**ham radio**

# a diagnostic serial data latch

## Convenient method of characterizing bit streams

**I needed a convenient way** to diagnose unsuccessful communication between two serially linked devices — a computer and printer, for instance. The serial data latch (SDL) I built monitors bit-stream or byte-oriented communication like RS-232.

Before developing the SDL, I used an oscilloscope and forced repetitive transmission of some character by one of the devices to confirm the number of data bits, stop bits, and parity. Watching the voltage levels on the oscilloscope trace to do this was inconvenient. The serial data latch catches one-time character transmissions and makes monitoring the dynamic transmission characteristics of the communication link easier. Combined with a break-out box to watch the more static "handshaking" lines, it is possible to have a complete system for determining the character of serial communication.

Most serial communication between personal computers conforms to the RS-232C standard. The SDL operation is described in terms of monitoring these signals. *Any bit stream link may be characterized* by modifying output interpretation.

You'll need knowledge of RS-232 communication to understand the descriptions in this article. Two devices are used for RS-232 data transfer: Data Terminal Equipment (DTE) and Data Communication Equipment (DCE). The names DTE and DCE originated when terminals began to be linked via communication equipment (modems) to large host computers. In the field of personal computers, such a distinction may be superfluous and distracting[1], but it is present.

Both DCEs and DTEs use DB-25 connectors 25 pin connectors with 12 pins on one row and 13 on the next, numbered from 1 to 25. Theoretically, a DCE should always use a female connector while the DTE uses the male plug[2].

Pins 4-6, 8, and 20 are used as data flow control signals. Articles have been written on how to correctly use these pins, but nonstandard methods abound in personal computer systems[3]. The original standard was designed for 110-baud (bit/second) terminals and modems. With higher speed communications now commonplace, a cleaner method of data flow control (at least in terms of how many wires link the devices) is to embed data flow requests in the data instead of adding hardware. The XON/XOFF protocol is one method used by personal computer programmers.

With this protocol you need to connect only three signal wires (see **table 1**). To tell if a device is acting as a DTE or DCE, use a voltmeter to measure the voltage on pins 2 and 3, using pin 7 as the reference. One should provide a significant reading; the other will be somewhere near 0 volts. The pin transmitting the data provides the voltage reading. This works whenever the device is on — not just when it is ready to send or receive data.

All data is carried on pins 2 and 3; the DTE transmits on pin 2 and the DCE on pin 3. The functions of the wires connecting the two are named with respect to the DTE: pin 2 is called *transmit data* (TxD) and pin 3 *receive data* (RxD), even though *each* transmits data from its associated device.

**By Brian J. Mork, KA9SNF**, 215 Paddock Drive East, Savoy, Illinois 61874

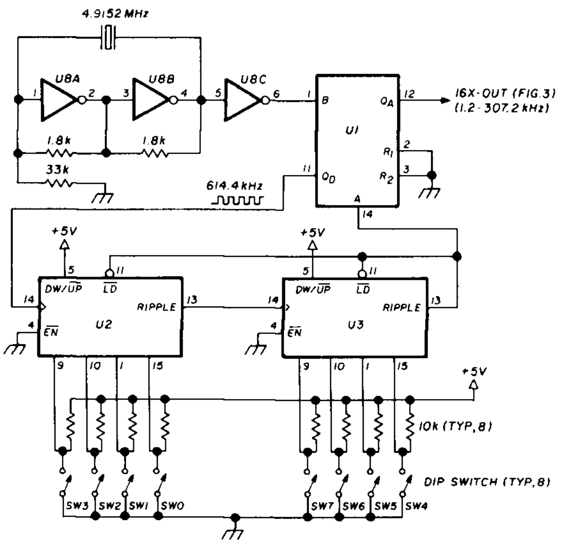


fig. 1. Baud rate generator schematic.

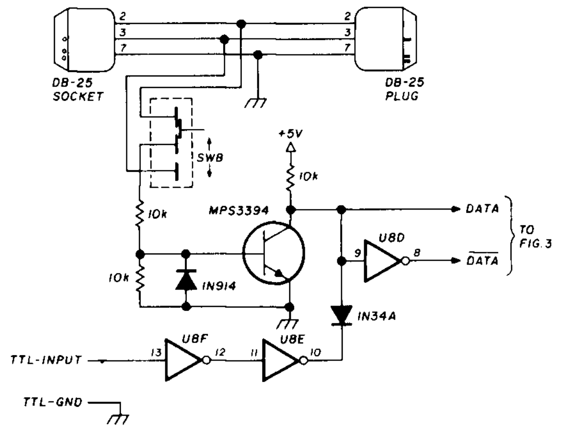


fig. 2. Input signal conditioning portion of the serial data latch.

**Table 1. RS-232 standard dictates that a zero data bit ("space") be indicated by a voltage of 3 to 25 volts. A one data bit ("mark") is indicated by a voltage of −3 to −25 volts (voltages are to be measured into an open circuit load). Typically ± 12 volts is used. The quiescent state of a data line (no data being sent) is marking.**

**pin 2: Voltage controlled by DTE and monitored by DCE ("TxD")**

**pin 3: Voltage controlled by DCE and monitored by DTE ("RxD")**

**pin 7: reference for above two voltages**

To transmit, by definition, is to control the voltage on a wire. To receive data, the voltage is monitored. All voltages are relative to pin 7 — the logical circuit ground at both the DCE and DTE. Pin 1 of the DB-25 connector, the frame or chassis ground, should be connected to the inside of the metal cabinet of the computer or peripheral. Many times only three wires are used; the pin 1 connection is neglected. If each device is designed properly and powered with a grounded three-prong AC plug, the level of communication link integrity and personal safety should be acceptable.

Data is transmitted on pins 2 and 3 in a bit serial format (one bit at a time). If ten bits need to be transferred, they are sent one after another at specific intervals in a predetermined order. Each bit of data is asserted for the *bit time* which is equal to the reciprocal of the bit/second (baud) rate. The SDL records the voltage level on pin 2 or 3 (your choice) relative to pin 7 at different times. The voltage level at these times reflects the zero/one status of the bits of the data being sent and the start and stop bits. The "different times" are defined by a baud rate generator (BRG) which, in this context, is a variable speed clock generating a frequency at 16 times the baud rate.

## circuit description

**Figure 1** shows a baud rate generator circuit capable of creating a 16x-out signal in the 1.2-to-307.2 kHz range for communication rates of 75 to 19,200 bits per second.

The 4.9152-MHz crystal combined with three inverting gates of U8 provide a TTL (transistor-transistor logic) compatible clock. Counters B, C, and D of U1 divide the signal by 8 and provide a 614.4-kHz symmetric clock at pin 11 of U1.

U2 and U3 are configured as down counters that decrement on the rising edge of the 614.4-kHz signal. At some point, the rising clock edge will cause them to decrement to 0. As a result of the subsequent falling edge, pin 13 of U3 goes low causing the counters to reload with a value set by the DIP (dual in-line package) switches SW0-SW7. As soon as the counters load, pin 13 output rises (the count is no longer zero), causing counter A of U1 to toggle the $Q_A$ output on pin 12. By changing the DIP settings, a variable frequency symmetrical square wave is available as 16x-out.

The DIP switches can be interpreted as a programmable divisor. Take, for example, a divisor of 1. This is the smallest divisor possible, and provides the fastest 16x-out frequency. On U2 and U3, a divisor of 0 (all DIP switches closed) gives the same results as a divisor of 1, but this mode of operation is not recommended. Dividing the 614.4-kHz signal by 1 provides a 614.4-kHz signal to counter A of U1, which divides

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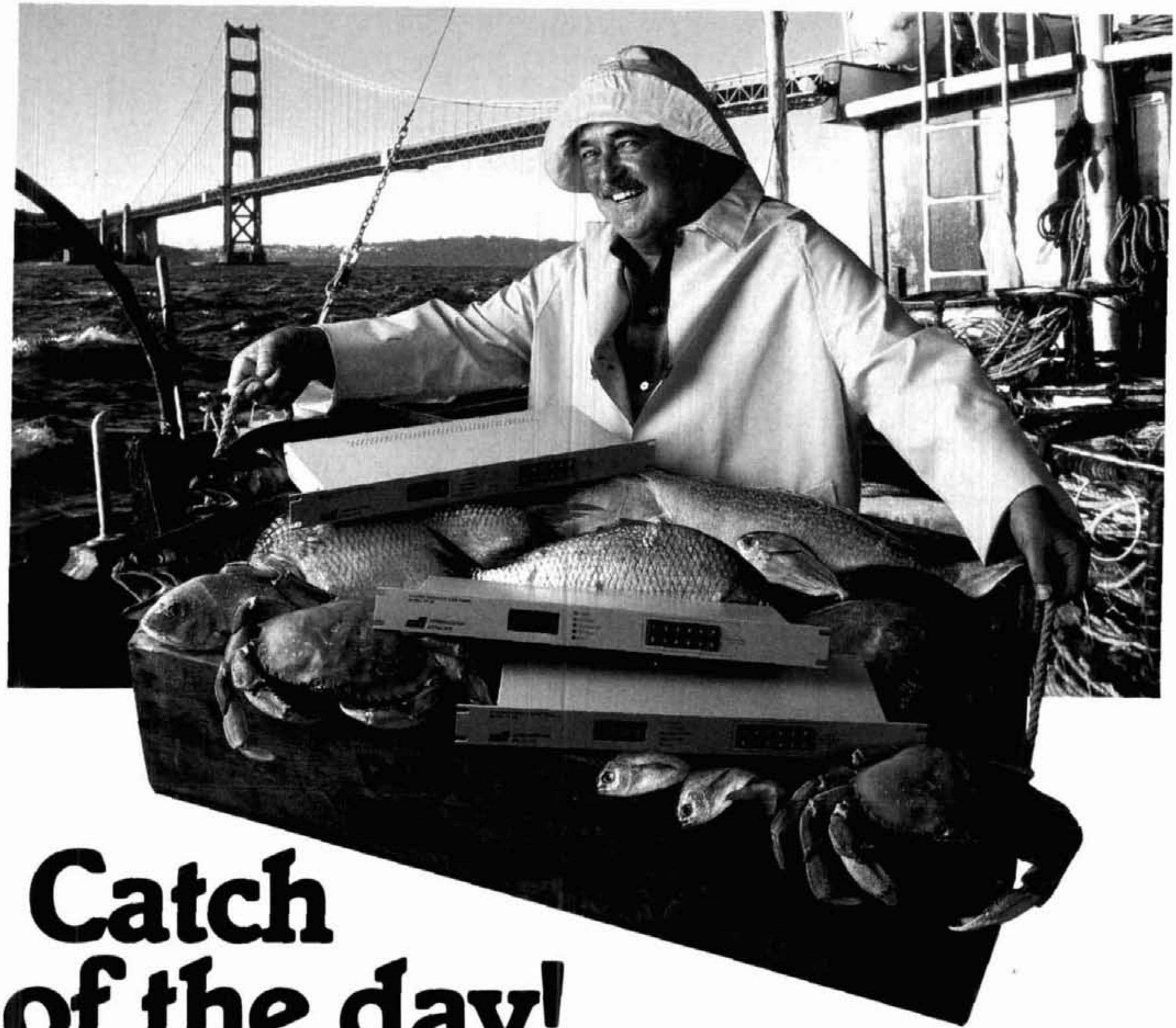

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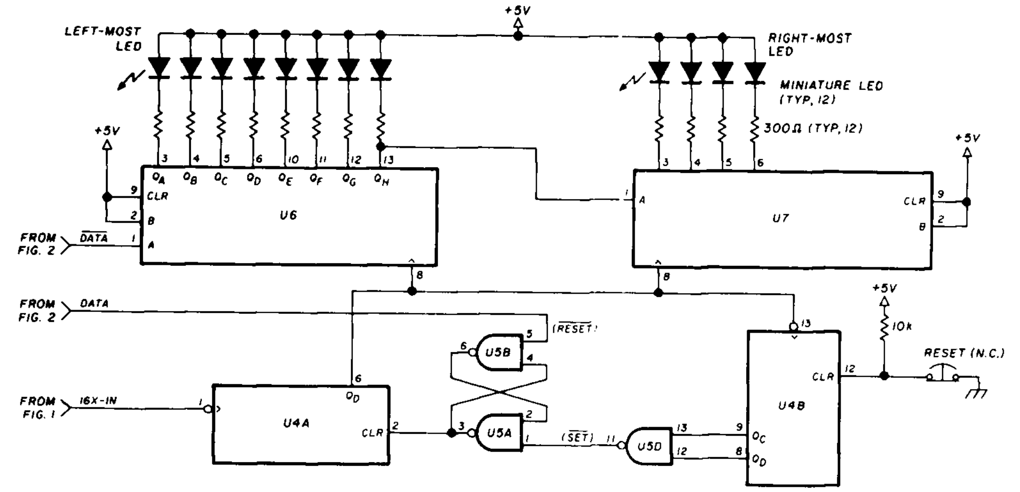



fig. 3. Clocking and display logic schematic.

the frequency by 2 to provide a symmetric 307.2 kHz-signal as 16x-out. This is 16 times the fastest baud rate commonly used with personal computers: 19,200 baud. Divisors for other baud rates can be found in **table 2**. For nonstandard baud rates, use the formula:

$$DIVISOR = \frac{19200}{baud\ rate}$$

Round the divisor to an integer, convert it to binary notation[4] and set it on the eight DIP switches. SW0 is the least significant bit (LSB) and SW7 the most significant bit (MSB).

Single chip programmable clocks are available and might replace the 3-1/2 chip baud rate generator described above. I designed the BRG using ICs I know are commonly available.

The input section shown in **fig. 2** conditions the TTL or RS-232 data from one of three data sources and provides normal and inverted data outputs.

The transistor buffers the nominally $\pm 12$ volt data lines, inverts the polarity and converts the signals to TTL compatible voltage levels. If nothing is connected to the DB-25 connectors, the transistor outputs marking status. The schematic calls for an MPS3394, but most NPN signal transistors will work.

The optional TTL input is twice inverted and wire-ORed with the transistor output. The double inversion attempts to preserve most of the noise immunity of the TTL gates by providing a locally (inside the SDL box) generated clean signal. Special noise considerations are needed because of the known voltage drop of the diode between U8e and U8d. Almost any germanium signal diode can be used in this application. The schematic calls for a 1N34A.

Using a transistor and a diode OR gate sacrifices simplicity as compared to RS-232 receiver/voltage converters like the Motorola 1489 and a TTL OR gate. But, the circuit as shown can accept both TTL and RS-232 signals with "automatic selection" — plug in the one you want to use.

The remaining circuitry (**fig. 3**) provides clocking logic and latches the data to be displayed on the LEDs. U5a and U5b act as a flip-flop. When the input data goes low (a start bit), the flip-flop output is reset low, releasing U4a to count pulses from 16x-in. U4a is configured as a divide-by-16 counter providing a symmetric $Q_D$ output equal to the baud rate.

Halfway through the bit time (eight oscillations of the 16x-in), $Q_D$ goes high, causing U6 and U7 to shift in new data. After the full bit time, $Q_D$ goes low and U4b increments by one. Halfway into the next bit time, $Q_D$ goes high again and shifts in the next data bit. This shift-and-count continues until U4b reaches 12 (both $Q_C$ and $Q_D$ outputs go high). U5d causes the flip-flop to go high, holding U4a in a cleared state. The data line may continue to change, but no more data is shifted into the LED shift registers. Opening the reset switch clears U4b, allowing the next start bit to cause 12 more bits to be latched.

The latched, inverted data is displayed on the LEDs by using the parallel outputs of the shift registers. If the data bit was a 1 (inverted data was low TTL) the corresponding LED will light. I call for 300-ohm current limiting resistors in the schematics, but used 390-ohm resistors because they were available. You can get a brighter display by lowering the resistor values to a minimum of about 100 ohms.

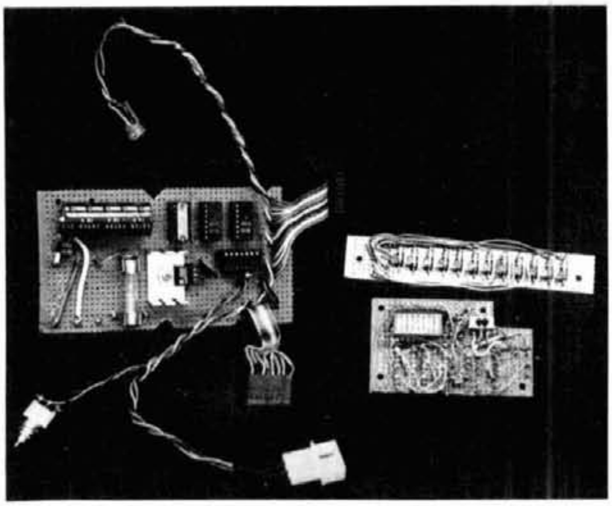
The power is supplied by a 1/2 ampere (minimum) 5-volt supply. I used a three terminal fixed-voltage regulator (7805) based circuit, but you can use any equivalent power supply. If you choose a 7805, mount it on a heat sink as it will be sourcing current near ca-

**Table 2. DIP switch settings for common baud rates. See the text for calculation of settings for non-standard baud values.**

| Bits/second (baud rate) | DIP switch settings (76543210) |
|---|---|
| 75 | 11111111 (1 = open) |
| 110 | 10101111 |
| 300 | 01000000 |
| 1200 | 00010000 |
| 2400 | 00001000 |
| 4800 | 00000100 |
| 9600 | 00000010 |
| 19200 | 00000001 |

**Table 3. Power connections, ground connections, and unused pins for all ICs.**

| | type | +5 volts | Ground | Not connected |
|---|---|---|---|---|
| U1 | 7493 | 5 | 10 | 4,6,7,8,9,13 |
| U2 | 74191 | 16 | 8 | 2,3,6,7,12 |
| U3 | 74191 | 16 | 8 | 2,3,6,7,12 |
| U4 | 74393 | 14 | 7 | 3,4,5,10,11 |
| U5 | 7400 | 14 | 7 | 8,9,10 |
| U6 | 74164 | 14 | 7 | - none - |
| U7 | 74164 | 14 | 7 | 10,11,12,13 |
| U8 | 7404 | 14 | 7 | - none - |



**My version of the SDL was built on three perfboards. The largest holds the power supply and clocking logic of *fig. 3*. The long thin LED display board, the BRG (with the block of dip switches), and all ""external" connections branch off this main board. The BRG board also supports the slide switch shown in *fig. 2*.**

pacity and getting warm. There is more information available about the 7805 or alternate designs[5].

## construction

Everybody has his way of constructing an electronic project. I won't tell you how I'd do it if I were you, but to aim beginners in the right direction, some general comments are in order.

I've had success with perfboard construction using a hybrid of solder and wire-wrapping. As you see in the construction photo, I made three separate boards linked by ribbon cables. Be generous with connectors.

First lay out large components like power supply parts and IC sockets; then solder power supply connections to all sockets and other durable components (capacitors, pull-up resistors, LEDs) that aren't easy to wire-wrap. Before installing additional components, check for proper application of power to this subassembly. Testing after the framework of the circuit is established prevents most damage. A voltmeter can be used since the voltages are not time dependent. Once the basic layout works, solder any "off-board" wiring (to the reset switch and DB-25 cable) to posts inserted in the perfboard. Finally, wire-wrap the rest of the connections and install the ICs.

Solder provides low resistance paths for the high current connections, with immunity to noise and TTL switching transients. If a mistake is made, it's easy to correct because the boards are uncrowded by signal wires. On the other hand, wire-wrapping allows for easy correction or modification of signal wires.

The power and ground connections, and the IC pins to be left unconnected, are given in **table 3**. All resistors should be 1/4 watt. Switch SW8 works best as a slide switch. The LED and DIP switch pull-up resistors take less room if put in single in-line packages. The RS-232 connections should use two DB-25s (one male, the other female). I made other external connections using a female miniature header. A two-piece aluminum box holds the circuitry but almost any enclosure is suitable. Other circuit details are found on the schematics.

## operation[4,6]

The first half of this section describes how to set up the BRG/SDL for use; the second explains how to interpret the information. Normal setup of the SDL involves plugging it in, providing a clock signal, and connecting it to a data source or between two devices (it passes the data unaltered). Block diagrams of different ways to use the BRG/SDL are shown in **fig. 4**.

The data to be latched may come from one of three places: pin 2 or 3 of the DB-25, or the TTL input. RS-232 compatible voltage levels must be provided to either the male or the female connectors (see **table 1**) if pin 2 or 3 or the DB-25 is used as a data source. Either connector may be used as input and the other is then available as output. With switch SW8 you can monitor either the DTE or DCE transmissions (pin 2 or 3, respectively).

The TTL input won't normally be used, but does

allow direct connection to the TTL compatible serial outputs of universal asynchronous receiver-transmitters (UARTs) like the 8250 or 8251 (avoiding the hassle of converting to RS-232 signals if they aren't otherwise available). The TTL input is measured against the SDL common (pin 7 of the DB-25 or equivalently the TTL-gnd input). Quiescent TTL data line state is high or "marking" with the start pulses going to low or "spacing" status.

You should connect either an RS-232 *or* TTL source. If you connect both, the circuit will not be damaged, but the results on the LED display may not be as described below.

Connect the 16x-out and 16x-in to use the internal BRG (**figs. 4A, 4C,** and **4F**). To use an external clock, leave 16x-out disconnected and connect the clock to 16x-in. Be sure to provide a good voltage reference for the TTL-compatible clock input. If the clock is relative to the same logic ground as pins 2 and 3 (the two grounds are connected inside the peripheral or computer and are available on pin 7) and the DB-25 is connected, you only need one wire. You can often access the 16x clock by taking the cabinet cover off the data source (your computer or other device) and connecting 16X-in to an appropriate integrated circuit pin (pin 9 of an 8251 operating in the 16x mode[6] or pin 15 of an 8250, for example). This is shown in **fig. 4B**. If the clock ground and pin 7 ground aren't connected via the DB-25 connector, two wires must be carried from the clock source (**figs. 4D, 4E,** and **4G**). In this case, connect the clock reference to the TTL-gnd input (which in turn is still connected to pin 7 of the DB-25 connector inside the SDL). Although this project allows the versatility of external clock sources, the integral BRG is normally used.

You must set the eight-pin dip switch to use the internal BRG. Settings for common baud rates are shown in **table 2**. A formula for nonstandard baud rates is provided in the circuit description section of this article.

After setting up the clock and data sources, plug in the SDL. No switch is provided — the SDL is always on. The LEDs show random on-and-off status and data input will be ignored. Reset the SDL by pressing the reset button. As soon as the data line goes to spacing status, a start bit is occurring, and 12 consecutive bits will be latched to the display.

When accepting RS-232 data, the LED on the far right should always be off, corresponding to the start bit, which is sensed when the data line goes from marking to space status. If it is on, either the SDL is malfunctioning, the baud rate of the transmitter is too fast, or the BRG is set too slow. This happens because subsequent data bits arrive too rapidly and get latched as the start bit.

Moving from right to left, the next eight LEDs reflect the data sent (assuming 8 data bytes — otherwise the next seven LEDs for 7 bits of data, and so on). Since the LSB is always sent first by RS-232 standard, the bit next to the start bit is the LSB. By referring to an ASCII table, you can determine what data was sent by the computer.

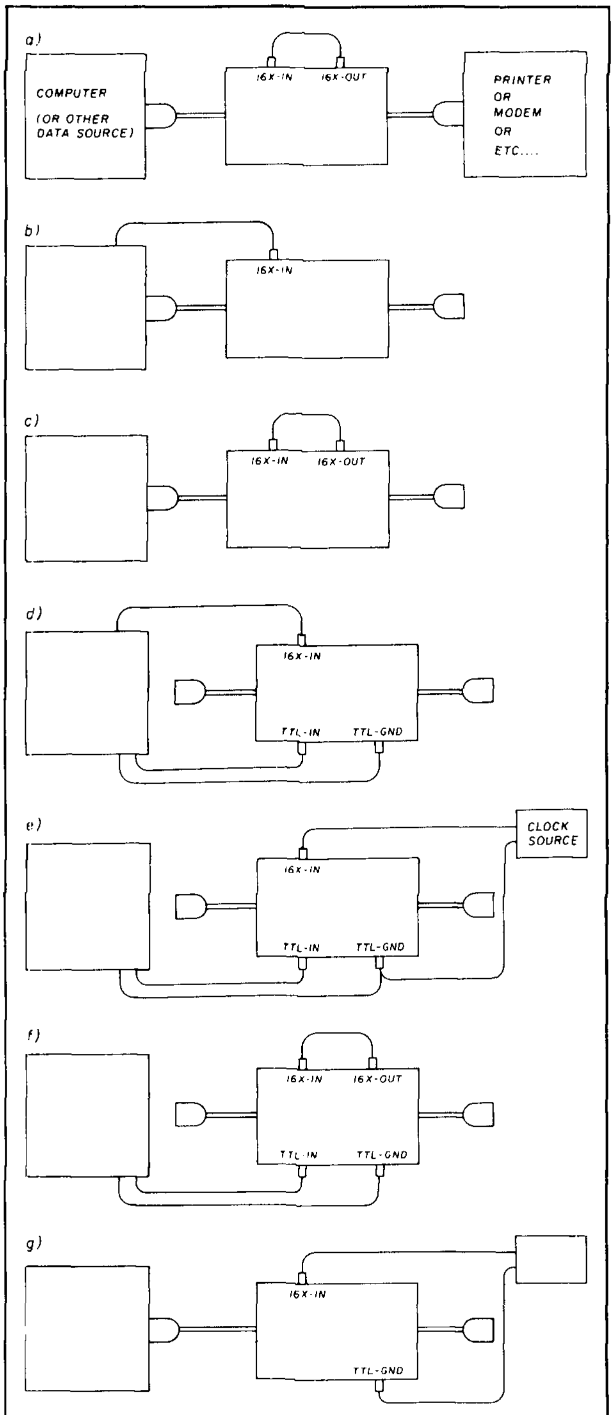



**fig. 4. Illustration of several possible methods for using the SDL/BRG. Probably the most common setup is shown in A. See text for more complete setup instructions.**

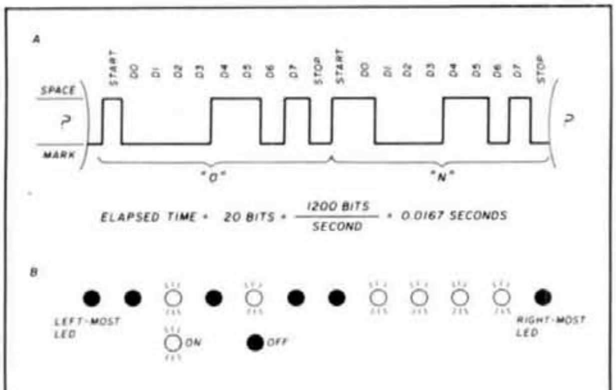



**fig. 5. (A)Condition of an RS-232 data line sending the word ""ON" as fast as possible at 1200 baud with 8 data bits, no parity bit, and 1 stop bit. (B)Condition of the 12 SDL LEDs if the above data was received after reset.**

An unknown transmission rate can be determined if it is a "standard" one (as listed in **table 2**). To do this, set the BRG for 19,200 baud. Reset the SDL and send a delete character (all data bits are mark status — opposite from the start bit) through the latch. The first data bit LED (the one just left of the start bit) may be on or off. If it is off, the device is transmitting slower than 19,200 baud. Move the DIP switches to the 9600 baud positions. Reset the SDL and send another delete character. Continue decreasing the baud rate until the first data bit LED goes on. This corresponds to the standard baud rate being used by the data source.

To the left of the data bit LEDs is the stop bit display. It will be on. The stop bits (there must always be one or more) serve two functions:

•a time delay to allow the UART to collect bits into a coherent byte and make it available to the peripheral controller,

•to force the data line to a status different than the next start bit.

If there were no stop bits and a character ended with the line in start bit status, you could not tell when the real start bit of the next character was sent. When the next character's start bit immediately follows the stop bit, the stream of characters is moving at its highest speed — see the diagram for sending the word "ON" (ASCII decimal values 79 and 78 or 01001111 and 01001110 in binary) in **fig. 5A**. The stop bit(s) follow the start bit at different times depending on how many data bits there are. A parity bit, if there were one, would appear between the data and the stop bit and shift the stop bit one more bit time later.

LEDs left of the stop bit are extras and normally match it (are on). If these LEDs are off, another start bit was latched. For example, if the SDL were reset and the word "ON" was sent as in **fig. 5A**, you would see the LED pattern shown in **fig. 5B**.

By sending different characters and monitoring the LEDs, you can use the SDL to determine a baud rate and confirm the presence of start, stop, and data bits. Verifying the operation of a communication link is often part of solving a larger problem, and this device allows you to confirm or rule out a problem in this area.

If you build an SDL using my design or your own I'd love to hear from you. If you have any questions, just write. Please include an SASE if you want a reply.

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5. 78xx regulator data in *National Semiconductor's Linear Data Book*; *1984 Radio Amateur's Handbook* Chapter 5; "Circuit Cellar," *Byte*, July 1985.
6. Intel 8251 data sheet, *Microsystem's Component Handbook, Volume II*. Pin 9 can be programmed to be accepted as 1x, 16x, or 64x the baud rate.

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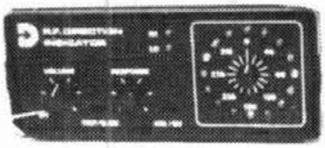

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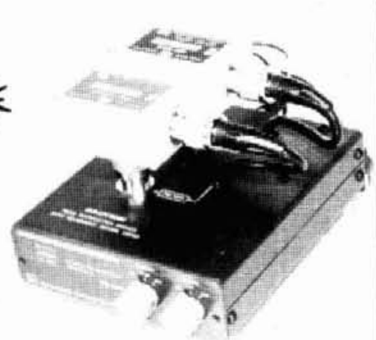

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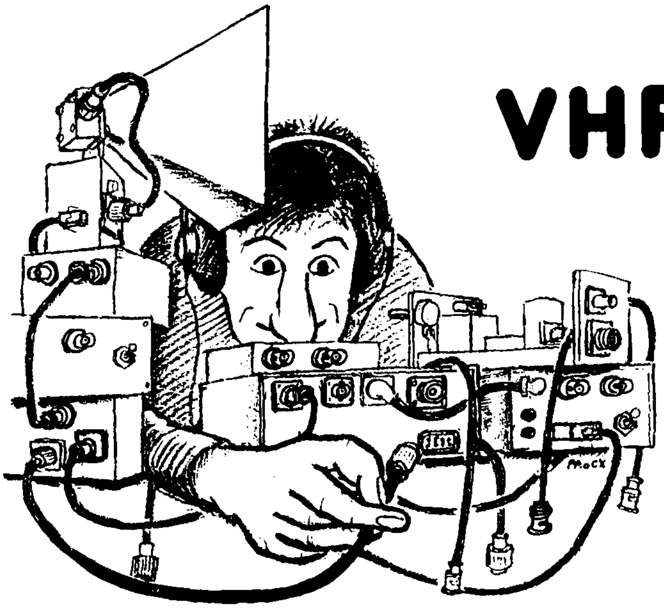

# VHF/UHF WORLD

Joe Reisert, W1JR

## microwave components and terminology: part 2

**Last month** we talked about rapid changes in the state of the art (SOA) — some older microwave components are either becoming extinct or moving much higher in frequency. Because their names, usefulness, and modes of operation are often lost during times of transistion, the March and April columns are devoted to them.

In March our primary focus was microwave transmission lines and waveguides. This month we will discuss other microwave components and terminology.

## couplers

There are many types of couplers used to monitor and couple energy into or out of a transmission line. The simplest are bidirectional and nothing more than voltage dividers using resistors, capacitors, or transformers as shown in **figs. 1A, 1B,** and **1C,** respectively. In each case the value of the component can be adjusted for the desired coupling factor.

Bidirectional couplers are convenient for reducing power and monitoring the signals on a transmission line with little or no insertion loss to the primary source. The main disadvantages are that the output level is often inaccurate and varies with component value choice and VSWR on the main line.

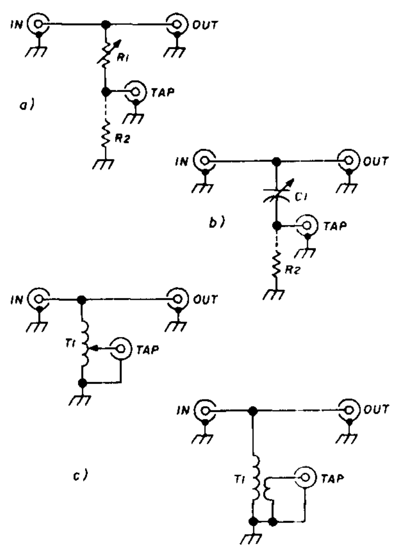


**fig. 1. Simple bidirectional couplers (A) resistive divider. $R_1$ sets coupling factor; $R_2$ may be used to stabilize level, (B) capacitance divider. $C_1$ sets coupling; $R_2$ (if needed) may be used to stabilize level, (C) transformer divider. Either tapped or conventional transformers are usable.**

Directional couplers, useful from hf through microwave, consist of two transmission lines loosely coupled together in such a way that a wave traveling in one direction in the main line excites a unidirectional wave in the other line. On the hf and VHF bands, hybrid couplers are fabricated with special transmission line transformers.

The difference in the rf level between the main line and the coupled port is called the coupling factor. It is usually specified in dBs, and easily controlled. Typical coupling factors are between 10 and 40 dB. The lower the coupling factor, the greater the power loss through the coupler. For instance, a 10-dB hybrid coupler would have an insertion loss of at least 0.45 dB and a 20-dB coupler only 0.05 dB.

In an ideal directional coupler, waves propagate in one direction as shown in **fig. 2A**. Isolation between the output and the uncoupled ports is referred to as "directivity" and expressed in dBs. High values of directivity imply better performance, with an "average" coupler exhibiting 20-25 dB directivity and a superior unit 30-40 dB.

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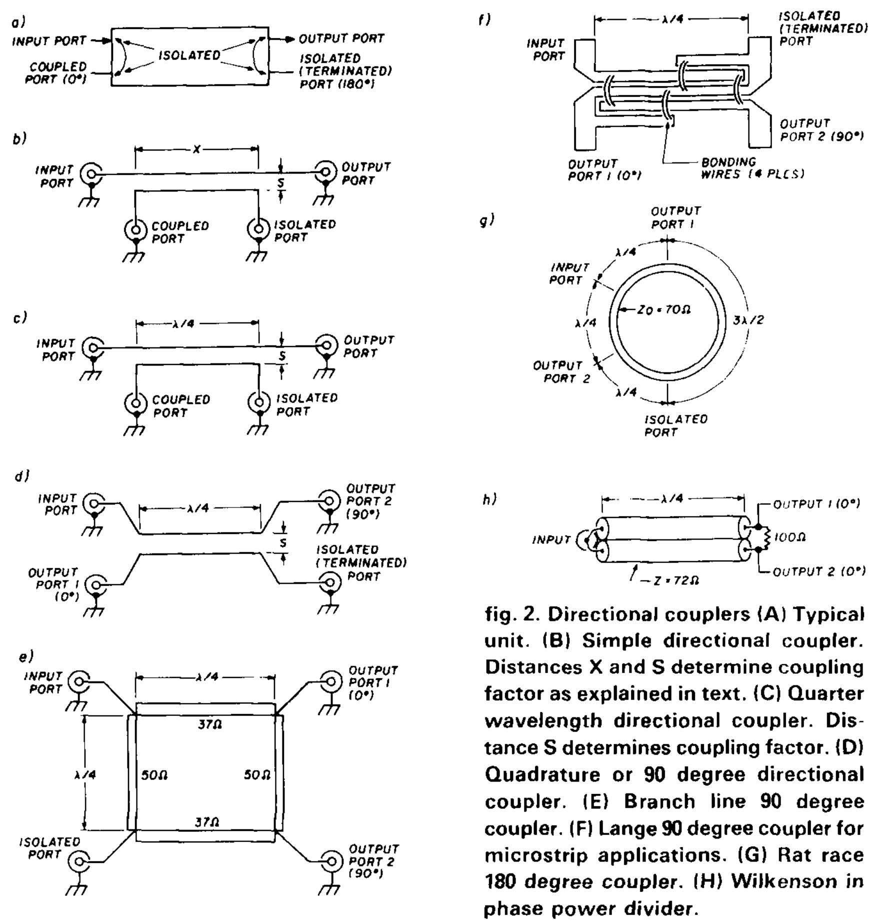

**fig. 2. Directional couplers (A) Typical unit. (B) Simple directional coupler. Distances X and S determine coupling factor as explained in text. (C) Quarter wavelength directional coupler. Distance S determines coupling factor. (D) Quadrature or 90 degree directional coupler. (E) Branch line 90 degree coupler. (F) Lange 90 degree coupler for microstrip applications. (G) Rat race 180 degree coupler. (H) Wilkenson in phase power divider.**

lers are often made up of coupling loops or short wires placed in the vicinity of a transmission line (see **fig. 2B**). Coupling is a function of the length (X) and spacing (S) of the probes to the main or inner conductor of the transmission line. Longer coupling lines (up to 0.25 wavelengths) and closer spacings (to the main transmission line, X) equates to higher coupling to and loss through the main line.

If the coupling line is very short, it takes the form of a magnetic (current) coupling. When it is long, typically 0.1-0.25 wavelength, it is an electric (voltage) coupling. The "monimatch" is a magnetic type of coupler which is usually more frequency sensitive and has only moderate directivity.[2,3]

The quarter wave (**fig. 2C**)[4] is the most common directional coupler used in the UHF and microwave region. It has a very constant output over approximately 30 percent bandwidth. Throughout this range the output and directivity of the coupled port are steady. Some construction examples are described in references 4 and 5.

Quarter-wave couplers can also operate at the third harmonic, so a 432-MHz coupler is probably useful at 1296 MHz. Commercial couplers are sometimes designed with multiple coupled sections in tandem, allowing them to work over extended frequency ranges. This kind of directional coupler usually has higher insertion loss and is considerably larger (in length) than narrower bandwidth types. Also note that many couplers are terminated internally and appear outwardly to be only three-terminal devices.

Couplers have many uses: one is to monitor power. **Figure 3A** shows a coupler used as a wattmeter monitoring the output of a transmitter. **Figure 3B** shows how a directional coupler can be used to monitor VSWR.[5]

The injection of local oscillator signals into a mixer is another microwave application for directional couplers (see **fig. 3C**). Couplers can also be used as output levelers for monitoring frequency, and on a system's input for signal or noise injection.

## quadrature couplers

The quadrature, or 90 degree, is a special type of coupler often referred to as a 3-dB coupler. Its outputs are equal in amplitude, but 90 degrees out of phase (**fig. 2D**). When first introduced, quadrature couplers consisted of two very tightly coupled quarter-wavelength lines. In the simplest physical configuration, they were two very tightly coupled transmission lines (usually striplines) sandwiched together and separated by a thin dielectric.[6]

Other UHF and microwave equivalents like the Wireline™, branch-line, and Lange couplers are now popular since they are easier to build.[7,8,9,10] Sage Labs developed Wireline to provide a unique line section that can be conveniently cut to the proper length. It looks like a piece of shielded twin lead with the wires separated only by their enamel coating.

The branch-line coupler is shown in

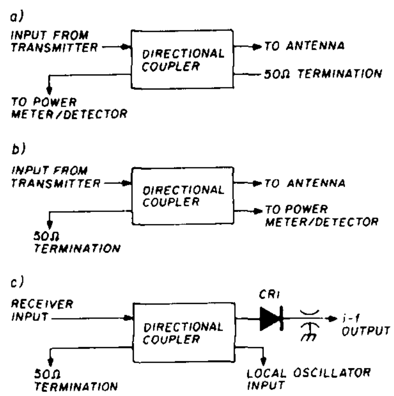

**fig. 3. Coupler applications. (A) Transmitter power monitor. (B) A VSWR monitor. (C) Mixer application. $CR_1$ is a mixer diode. Directional coupler is typically 7-10 dB, hence the local oscillator power must be increased by a similar amount.**

fig. 2E.[8] It is easy to construct, especially in microstrip. The Lange coupler, fig. 2F, was developed for applications where a small quadrature coupler was required in hybrid circuits.

Quadrature hybrids are popular for generating circular polarization and combining power amplifiers.[6,8] Other applications and examples are described in references 7 through 10.

## hybrids

The hybrid coupler is usually a device with either in phase (0 degree) or out of phase (180 degree) outputs.[7] The "rat race" shown in fig. 2G[10] is a common microwave version often used in balanced mixers.

Another hybrid is the Wilkinson in-phase power divider that provides two in-phase outputs of equal power level in isolation from each other. It is used where dual outputs are required, as in local oscillators and transmitter power division and addition.[10]

## circulators and isolators

Circulators and isolators may be among the most interesting microwave components. The basic configuration is called a circulator — a three or more port nonreciprocal device using microwave ferrite material and operating on the principle of Faraday rotation.

The basic coaxial microwave circulator has three 50-ohm ports illustrated in fig. 4A. RF entering port A travels in only one direction (clockwise as shown) to the adjacent port, B, with very low attenuation, typically 0.1-0.2 dB. If there is any mismatch to the device connected at port B, it will be reflected to port C. Any impedance mismatch at port C will cause a reflection back to port A and so forth, always traveling in the same direction.

Circulators are used to provide good impedance termination to a receiver or transmitter. To do this, the third or C port is terminated with a well-matched 50-ohm load (see fig. 4B). In this configuration it is referred to as an isolator. The (reverse) isolation of a typical isolator is approximately 20 to 30 dB.

Figure 4C shows a typical receiver application that uses an isolator. Here

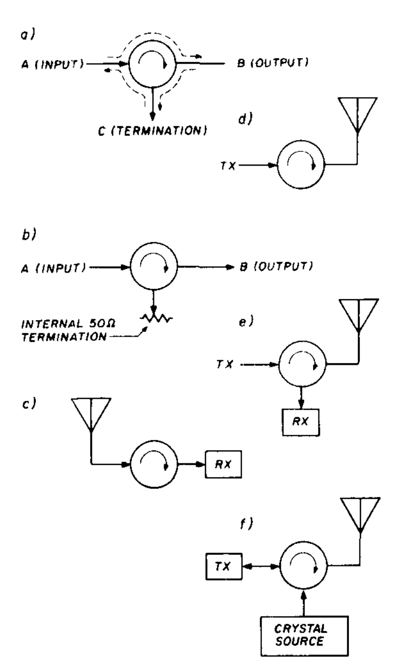


fig. 4. Circulators and isolator applications. (A) Typical circulator. (B) Typical isolator with internal termination. (C) Method to isolate receiver input from antenna using an isolator. (D) Method using isolator on output of a solidstate transmitter to lessen the possibilities of generating intermods see text. (E) Circulator used as a T/R switch. (F) Typical method of injection locking through a circulator as explained in text.

both the antenna and the receiver always see a good impedance match regardless of the actual device VSWR. Figure 4D shows how to use an isolator in a transmitter application. The advantage is that the antenna VSWR can degrade significantly without affecting transmitter operation.

The arrangement in fig. 4D has another very practical Amateur application. FM repeaters are often located where there are high levels of rf, especially when the antenna is co-located on a tower with other transmitting antennas. Any rf entering the output of a transmitter, especially one with a solid-state final, will cause nonlinearities in the output stage and may result in the generation of spurious outputs that look like other transmitted signals. Though a problem in the early days of fm repeaters, this has been significantly improved using ferrite isolators.

The use of a circulator in a TR (Transmitter/Receiver) configuration is shown in fig. 4E. If there is sufficient isolation between ports, mechanical T/R relays are not required. Even if relays are required, the circulator will increase the isolation and thus the protection of the receiver.

Figure 4F shows the stabilization of free-running transmitters using the principle of injection locking. A stable source (typically a crystal oscillator driving a multiplier) is coupled through a circulator, resulting in a stabilized transmitter.

## microwave amplifiers and oscillators

Older types of microwave amplifiers and oscillators abound.[12] Many use vacuum tubes and were developed primarily as components of RADAR systems because the triodes, pentodes, and similar available tubes had long transit times. Newer tubes often used the transit time in achieving their normal operation. Earlier microwave vacuum tube types were the klystron, TWT (traveling wave tube), BWO (backward wave oscillator), and magnetron.

The Varian Brothers invented the klystron prior to World War II. The basic amplifier form has an input cavity resonator (called the buncher), a field-free drift space, an output cavity resonator (called the catcher), and a collector electrode.[12] It requires a rather elaborate biasing scheme with floating supplies.

Klystrons are primarily used above 500 MHz and can yield high linear power gain (20-40 dB) at very high rf power levels at 30 to 40 percent efficiency in CW, SSB, or pulse modes. High-power klystrons are used by some Amateurs for power amplification on 1296 and 2304 EME.

The reflex klystron is a single cavity klystron configuration with a repeller. Often used as a low-power 1 to 20 milliwatt oscillator, reflex klystrons were popular in the early microwave days as local oscillators, pumps, and transmit-

ters. The klystrode, a more modern version of the tube, is a single cavity klystron with lower gain but higher efficiency.

The TWT's invention was first announced in 1946, but the tube was not available commercially until 1949 when Varian Associates released an S-band (2-4 GHz) amplifier.[12,13] It differs from conventional tube amplifiers in many ways. First, the power supply positive terminal is grounded. All the control elements of the tube (filament, cathode, grid, anode, and helix) must be floated with respect to the collector, which is at ground potential. DC voltages are usually regulated and often in the 1 to 2,000 volt range. Gain is very high, 30 to 50 dB, and typically flat over an octave bandwidth (e.g., 2-4 GHz).

The TWT can be designed as either a moderately low noise figure (3-7 dB) amplifier or a linear power amplifier for transmitters with power outputs exceeding 100 watts up through 10 GHz. Many TWTs are being replaced (at least at lower power levels) by SOA solid-state amplifiers because of the complexity of the power supply, moderate size, and high cost. This is a boon to Amateurs who often find "obsolete" TWTs on the surplus market! These tubes have recently been used as transmitter output power amplifiers for Amateur EME records on 3.4 and 5.6 GHz.[14]

The BWO, sometimes called the Carcinotron, arrived in 1963.[12] An outgrowth of the TWT amplifier, it is inherently a low output power (1-10 milliwatts) oscillator. Its name, backward wave oscillator, reflects the fact that electrons travel in a direction opposite from that in which the wave is propagated.

BWOs can be used at extremely high (100 GHz) frequencies. They are not too prevalent in the Amateur market but were widely used as the tuneable local oscillator in the early spectrum analyzers.

Many Amateurs are probably familiar with the magnetron — the typical power source in the 2450-2500 MHz microwave ovens found in today's kitchens. Primarily an oscillator that can be used either in CW or pulse modes[15], it played an important part in the development of high-power levels for the early radars.

In the magnetron, the electron flow from the cathode to the plate is mainly influenced by a magnetic field applied perpendicular to the cathode-anode path and by the field effects produced by the anode cavities. It uses large magnets, high voltages, and is usually operated in the pulse mode. However, as discussed in reference 15, the type in consumer microwave ovens is not suitable for Amateur operations.

## microwave solid-state amplifiers and oscillators

Solid-state devices, like vacuum tube microwave amplifiers, are widely used although they appeared later. Most applications use one of the many types of microwave diodes discussed in references 16 and 17.

The earliest solid-state microwave applications were mixers and detectors, first with germanium, and then silicon and gallium arsenide diodes. Development of the paramp (parametric amplifier), or negative resistance amplifier, followed using varactor diodes.[17] The late Sam Harris, W1FZJ, was influential in creating paramps for the Amateur.[18] Noise figures as low as 1.0 dB were reported for the first time making EME possible on 1296 MHz.

The paramp uses a pump or extra oscillator typically operating at five to ten times the amplifier frequency. Amateurs first used low-power reflex klystrons, and later Gunn diode oscillators (reference 17). Microwave circulators made paramps more stable by providing a good impedance match regardless of the load.

Microwave tunnel diodes (Esaki diodes) were also used as microwave detectors and oscillators. They were subsequently developed into negative resistance amplifiers, but the noise figures were only moderate and the dynamic range was poor. Most microwave amplifiers and oscillators now use silicon bipolar transistors, GaAs (Gallium Arsenide) FETs, and HEMTs.[19,20]

## other microwave diode applications

Diodes can be used as multipliers. Common types are varactors and SRDs (step recovery diodes). Noise diodes can be used for testing the sensitivity or noise figure of amplifiers. Limiter diodes are common in the microwave region as protection for other solid-state devices. This is particularly important since mechanical relays have less isolation at higher frequencies.[17]

## filters and filter elements

Discrete components like coils and capacitors are normally used on frequencies up through UHF, but as you go higher in frequency, capacitors often become inductive. Low values of inductance are also difficult or impossible to realize. For these reasons cavity-type filters became popular in the microwave region. **Figure 5A** shows a re-entrant cavity. The capacitor is often eliminated by adjusting the length of the inductor or center element.

Waveguide is often used as you go higher in frequency. Multiple section filters can be fabricated by placing partitions in a waveguide. Holes or cutouts are made to couple energy between sections; these openings are called irises. Screws or tuners are placed in the walls of the waveguide to tune the elements (reference 21).

Other filter elements are evolving. One is the YIG (yttrium iron garnet) sphere — a small resonant crystal structure that can be electronically tuned through the application of a magnetic field. The SAW (surface acoustic wave) resonator made from crystals is another being used for filters, replacing crystal resonators. It typically operates between 50 and 1000 MHz. Of more recent popularity are dielectric resonator materials used in DROs (dielectric resonator oscillators) or in tuners, as shown in **fig. 5C**.

## microwave power measurement

It is frequently necessary to determine microwave power levels. At very low levels (less than 10 milliwatts) this is often done with detector diodes as described in reference 17. At higher levels, a diode detector can be placed at a lower power level using a directional coupler as in **fig. 3A**.

Several other devices were developed to accurately measure microwave power up to the 100 milliwatt level. One, the bolometer (a resistor with a high temperature coefficient of resistivity), is usually mounted in a probe and connected to a bridge circuit which senses the rf power levels. Common bolometers are the thermistor, a resistance element made of a semiconducting material with a negative temperature coefficient; and the barretter, a metallic resistor with a positive temperature coefficient. They are used with detection circuitry that senses resistance change versus power level.

The calorimeter is another instrument used for microwave power measurement up through 10 watts. Usually a self-contained unit without an external probe, it detects heat through a self-balancing bridge that has identical temperature sensitive resistors in each leg.

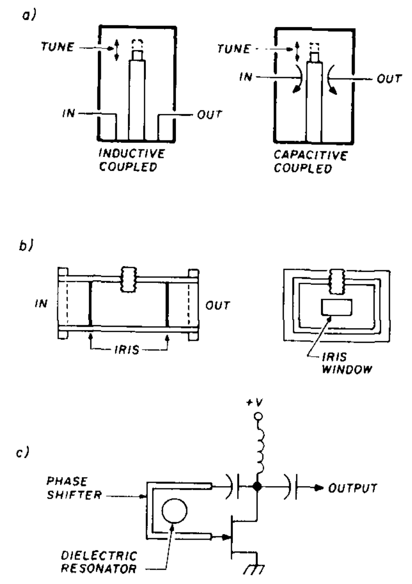


**fig. 5. Typical filters and resonators. (A) Cavity quarter wavelength filter either inductive or capacitance coupled. (B) Waveguide filter using iris coupling. (C) FET oscillator using dielectric resonator to stabilize frequency.**

## microwave frequency measurement

Wavemeters were used to measure microwave frequencies before the advent of accurate meters. Two basic wavemeter types are the absorption and reflective. The absorption type usually has a resonant filter and built-in detector which could consist of a frequency calibrated re-entrant cavity (see **fig. 5A**) inserted in the test setup in **fig. 6A** and followed by a diode detector.

Reflective wavemeters are still used, especially at microwave frequencies. They are usually made up of a tuned circuit lightly coupled to a waveguide (**fig. 6B**). When tuned to the operating frequency, they extract a minute amount of power causing a slight power drop in the main line. Because of its appearance, this wavemeter has been nicknamed the "coffee grinder".

Lecher and slotted lines are two other kinds of microwave frequency measurement gear. Lecher lines are primarily reserved for the VHF and UHF frequencies where balanced lines are used.

The slotted line is practical in UHF and microwave regions and can be found at flea markets (see **fig. 6C**). It is made up of a detector and narrow slot cut in a coaxial line or waveguide. A detector probe is inserted a short distance into the slot (and hence the line) to extract a small amount of rf power. If there is a slight impedance mismatch on the line, the probe can be moved back and forth between the voltage peaks. The physical distance traveled can be measured and converted to frequency.

## impedance matching

Impedance matching is a big problem, especially at microwave frequencies. Old-timers will jokingly say that they used to tune a waveguide by denting it with a ballpeen hammer — believe it! Nowadays screws or dielectric strips are often placed in waveguides or near a transmission line. Many of these techniques are explained in reference 21.

Discontinuities, imperfections, impedance changes, connectors, and fringing effects are particularly troublesome on the microwave frequencies because the wavelength is so short. As a result, greater attention must be paid to minor details, especially rf connectors.[22,23]

An older type of waveguide impedance matching used a sliding short — basically a piece of waveguide shunted across the line. These adjustable shorts are common at flea markets. Reference 21 describes this technique.

VSWR can be measured with directional couplers but the slotted line shown in **fig. 6C** can also be used. Expensive network analyzers are becoming popular especially with those who work in well-equipped microwave labs. These analyzers present impedance in the graphical form of a Smith chart.[24]

No discussion of impedance matching would be complete without mentioning the Smith chart, developed by the late Phillip H. Smith at Bell Labs. Smith charts basically convert Cartesian coordinates to a system of two orthogonal families of circles. The lines represent contours of constant reactance and resistance. Its use makes impedance matching much easier.

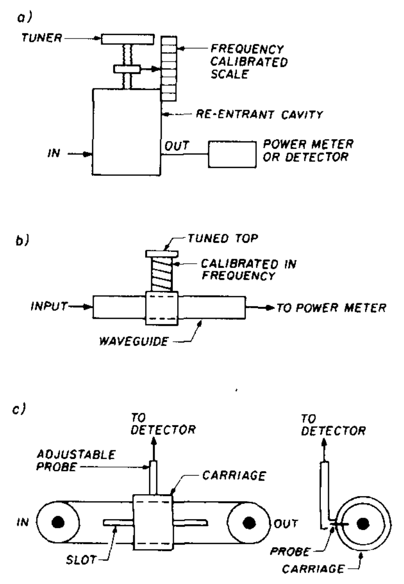


**fig. 6. Typical microwave frequency measurement schemes. (A) Absorption wavemeter. (B) Waveguide inline reflection type wavemeter. (C) Slotted line used to probe distance (and hence frequency) between voltage nulls as described in text.**

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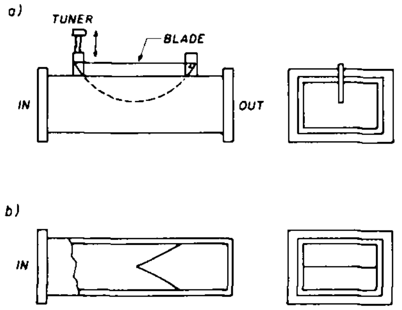


**fig. 7. Typical microwave waveguide attenuators and terminations as described in text. (A) Blade type of variable attenuator. (B) Cutaway view of a termination using tapered lossy dielectric.**

## attenuators and terminations

On frequencies below the microwave bands, attenuators and loads usually consist of a resistor or resistor network. This works fine since good carbon resistors exhibit low reactance. However, as you go higher in frequency, the reactance of most resistors becomes significant and it's no longer a low VSWR (pure) resistance.

Some stripline/microstrip loads and attenuators are available. Manufactured using vacuum deposited nichrome or other suitable materials on a ceramic substrate, they are usually expensive and have frequency limitations. Because of this, other attenuator and termination methods had to be developed on the higher frequencies. Carbon or microwave ferrite-type devices were often used. One special attenuator method was developed for waveguide. It consists of inserting a blade or rotary vane of carbon into the waveguide as shown in **fig. 7A**.

Terminations are another story. Often they are lossy absorbers, not terminations in the true sense of a resistor. **Figure 7B** shows one type consisting of a tapered section of lossy dielectric placed at the end of a waveguide. This type of attenuator can dissipate reasonable power since it's larger than average discrete resistors, but will usually not operate below some cutoff frequency, typically around 1 GHz.

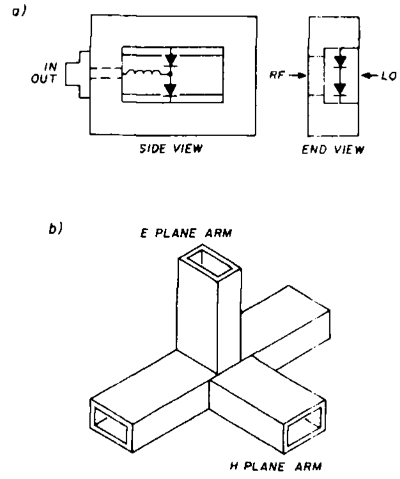


**fig. 8. Some microwave waveguide types of balanced mixers. (A) Orthomode. (B) Magic "T".**

## mixers

It wouldn't be fair to skip over microwave mixers since many of the types used today in the VHF/UHF region originally evolved in the microwave region! In fact, one of the first solid-state mixers used a single 1N21 point contact-type diode which became the standard of the radar industry.[16,17] Schottky/hot carrier diodes were first developed for microwaves and later for hf through UHF. Even the subharmonic pumped mixer (where the local oscillator is actually at one-half the normal frequency required) was first used on microwaves.

Balanced mixers with two diodes mounted in series across a waveguide have been around a long time. The Varian OrthoMode™ in **fig. 8A** was one of these. The magic "T" (see **fig. 8B**) was another popular waveguide-type mixer. As noted earlier, this configuration is actually a waveguide coupler. The rat race (**fig. 2G**) and the quadrature coupler (**fig. 2D**) are also used for driving balanced mixers frequently using waveguide.

## microwave spectrum analyzers

These instruments really make the life of a microwave engineer a lot easier.

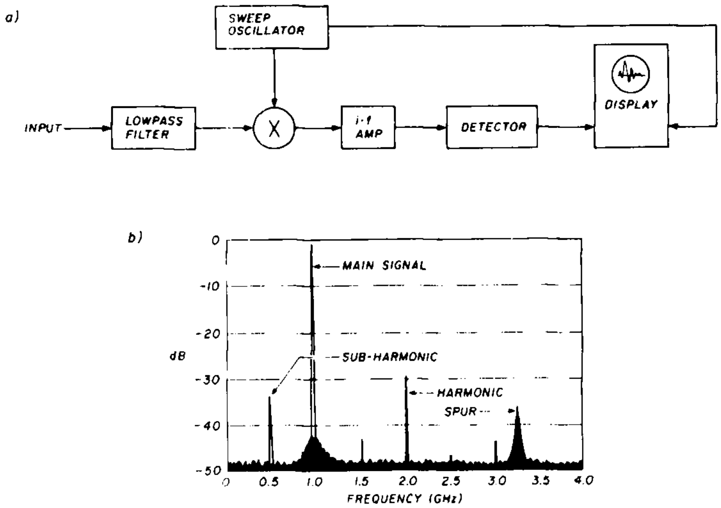


**fig. 9. Spectrum analyzers are great microwave tools. (A) Typical block diagram of a spectrum analyzer. (B) A spectrum display of 1.0 GHz local oscillator signal and harmonics, subharmonics, and spurii.**

The modern spectrum analyzer is similar to present-day hf upconverting superheterodyne receivers. The basic components are a low-pass filter, mixer, sweep oscillator, i-f amplifier, detector, and display as shown in **fig. 9A**

To simplify filtering, input signals are usually upconverted to an i-f above the highest possible input frequency. The signals are then amplified and downconverted to a lower i-f where gain and better selectivity are less expensive.

✓ 174

The detected output is displayed on an oscilloscope.

The beauty of a spectrum analyzer is that all the signal components are displayed so that the relative levels and undesired products are easily discernible (**fig. 9B**). Older spectrum analyzers are now appearing on the surplus market. Sometimes Amateurs who have access to one can help you see what your transmitter or local oscillator's output looks like. Beware; it may scare you!

## new VHF records

In last month's column, I mentioned that the 6-meter EME record had been extended.[1] On November 14, 1987, Ray Rector, WA4NJP (EM84DG), worked Jim Treybig, W6JKV (CM87WI), for a new record of 2148 miles (3457 km). Ray used four 8-element W1JR Yagis as described in the May 1987 *ham radio*, and Jim used two of the new 10-element M² (M squared) 50-foot boom length Yagis. Both ran 1500 watts.[27] The QSO took place with the moon setting on Ray's western horizon. To prove it wasn't a fluke, they repeated the contact on November 30th with the moon elevated at both ends. They spent a lot of time and effort to make this all happen. Congratulations again to Ray and Jim. Six-meter EME is now buzzing with activity. How long do you think this record will last?

### important VHF/UHF events

| | |
|---|---|
| April 11 | *ARRL 144-MHz Spring Sprint Contest (Monday evening local)* |
| April 13 | *EME perigee* |
| April 16 | *New moon* |
| April 19 | *ARRL 220-MHz Spring Sprint Contest (Tuesday evening local)* |
| April 21 | *Predicted peak of the Lyrids meteor shower at 1730 UTC* |
| April 27 | *ARRL 432-MHz Spring Sprint Contest (Wednesday evening local)* |
| April 29-May 1 | *Dayton Hamvention* |
| May 4 | *Predicted peak of the Eta Aquarids meteor shower at 1900 UTC* |
| May 6 | *ARRL 902-MHz Spring Sprint Contest (Friday evening local)* |
| May 10 | *EME perigee* |
| May 12 | *ARRL 1296-MHz Spring Sprint Contest (Thursday evening local)* |
| May 13-15 | *14th Annual Eastern VHF/UHF Conference, Nashua, New Hampshire (contact W1EJ)* |
| May 15 | *New moon* |
| May 21-22 | *ARRL 50-MHz Spring Sprint Contest (Saturday evening local)* |
| May 26 | *ARRL 2304-MHz Spring Sprint Contest (Thursday evening local)* |

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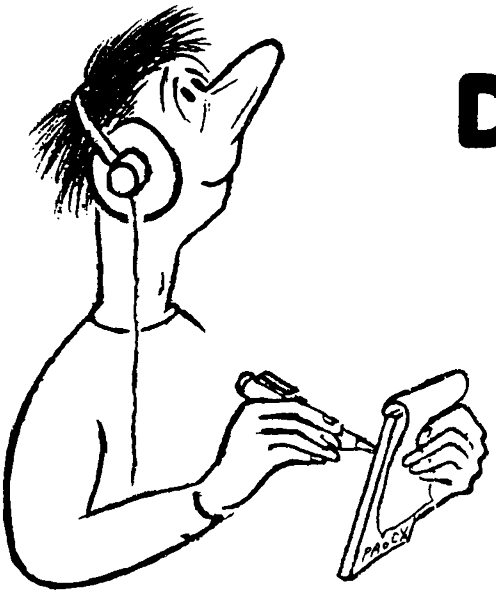
**ham radio**



# DX FORECASTER

**Garth Stonehocker, K0RYW**

## dx signal quality

**Most DXers** become quite proficient at copying weak, varying signals through QRM and noise. A greater occurrence of geomagnetic ionospheric disturbances with accompanying fading during the equinox season really makes one work. Studies on fading and signal quality may provide information allowing you to operate more effectively during this season.

Fading is characterized by the time interval between signal crests or troughs and by the amplitude change between these peaks and valleys, commonly called depth of fade. It is often accompanied by frequency distortion which is also used to characterize signal quality. Fade rate is defined as *intervals* per second. Signal fade can appear as either a decrease in (attenuation) strength or an increase (focusing) of signal amplitude. Flutter is a rapid fade rate in which several intervals (cycles) occur per second. One interval per second is called a fast fade, and intervals of several seconds or longer are known as long fades. *Flat fading* involves no frequency distortion, and *selective fading* includes frequency distortion within the bandwidth being used.

Most of the attenuation associated with fading occurs as the signal passes through the D and E regions of the ionosphere where the numbers of electrons are greatest, but electron motion becomes turbulent at times of disturbed geomagnetic fields. Fading depth and duration are not great from these regions.

The significant focusing and frequency fading characteristics come mainly from the F region of the ionosphere. Here fade depth and duration can attain any set of values between extremes. Signal variability is a function of distance since a great number of hops averages out the amplitude extremes. As distance between the transmitter and receiver increases the take-off angle lowers; that factor plus the multihop path both tend to lengthen the fade interval. For a *set* distance, the duration between fades *decreases* with the higher take-off angle if you increase the number of hops.

During the first few hours (positive phase) of disturbed geomagnetic field conditions in mid-latitudes, the fade interval is shorter than normal and lengthens to longer than normal in the remaining hours (negative phase). It slowly approaches normal values again in two to three days. Conversely, the fade rate is usually higher than normal during those first hours, sometimes up to a day, then slowly returns to normal in the remaining ones. This sequence is reversed in phase at lower latitudes closer to the geomagnetic equator. The extent to which fading affects communications also depends on the signal modulation that's employed. The type of communications least affected are CW, voice, and teletype respectively. As a general rule, higher speed data transmission is most affected. The ease of overcoming this difficulty depends on the speed (bit or mark/space length), the amount of redundancy built into the modulation, and the modulation type (FSK or PSK, coherent/synchronous or asynchronous, and the bit structure). The system can be designed to operate well in fixed links. The predominant type of fading can be overcome by tailoring the speed, redundancy, and modulation form to suit. For the most part, DXers have lived with fading for years and know almost instinctively the best mode to use "to get through". For most of us old DXers it is just CW with an occasional missing dit or dah.

## last-minute forecast

The lower frequency bands, for daytime short skip and nighttime DX, should be excellent during the first and last weeks of the month. Winter (low) noise conditions still prevail helping these lower bands, except during spring weather-front thunderstorm passages. Equinox geomagnetic disturbances may reduce MUFs around April 2, 11, 21, and 29, especially at night. The higher bands will be very good the middle two weeks of the month. Look for transequatorial openings to southern countries especially during geomagnetic disturbances when MUFs increase in the local afternoons and evenings.

The perigee of the moon's orbit (for moonbounce DX) is on the 13th, with the moon at full phase on the 2nd. There will be a short meteor shower, the Lyrid, on April 20-22 with a rate of five per hour — hardly much help for meteor-scatter DX. But a bigger shower, the Aquarid, starts before the end of April, peaks on the 5th of May, and ends in mid-May. Its rate is 10 to 30 per hour.

## band-by-band summary

Ten meters will be open to the south and southeast for an hour before local noon, to the south at noon and to the southwest in the afternoon. The openings will be longer when the solar flux is at its 27-day cycle maximum. Transequatorial openings are also best at that time.

Fifteen and 20 meters, almost always open to some part of the world, will be the main daytime DX bands.

## APRIL

### WESTERN USA

| GMT | 2300 | 2200 | 2100 | 2000 | 1900 | 1800 | 1700 | 1600 | 1500 | 1400 | 1300 | 1200 | 1100 | 1000 | 0900 | 0800 | 0700 | 0600 | 0500 | 0400 | 0300 | 0200 | 0100 | 0000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PST | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | |
| ASIA FAR EAST | 20 | 20 | 20 | 20 | 30 | 30 | 30 | 30 | 30 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 15 | 15 | 15 | 15 | 20* | 20 | 20 | 20 | 20 | N |
| EUROPE | 15 | 15 | 15 | 15 | 20 | 20 | 20 | 20 | 20 | 20 | _20_ | _20_ | _30_ | _30_ | _30_ | _30_ | _20_ | 20 | 20 | 20 | 20 | 15 | 15 | 15 | NE |
| S. AFRICA | 15 | 12 | 10 | 10 | 10 | 10 | 12 | 12 | 15 | 15 | 15 | 15 | _20_ | _20_ | _20_ | 20 | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | E |
| S. AMERICA | 12 | 12 | 15 | 15 | 15 | 15 | 20 | 20 | 20 | 20 | _20_ | _20_ | _20_ | _20_* | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | 10 | 10 | SE |
| ANTARCTICA | 15 | 15 | 15 | 15 | 15 | _20_ | _20_ | _20_ | _20_ | _20_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | S |
| NEW ZEALAND | 10 | 12 | 12 | 12 | 15 | 15 | 15 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | 15 | 15 | 15 | 12 | 12 | 12 | 12 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 12 | 15 | 15 | 15 | 15 | 20 | 20 | 20 | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 15 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | 12 | W |
| JAPAN | 20 | 20 | 20 | 20 | 20 | 20 | 20 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 15 | NW |

### MID USA

| MST | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASIA FAR EAST | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 20 | 20 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | _30_ | _30_ | _30_ | 30 | 30 | 20 | 20 | 20 | N |
| EUROPE | 15 | 15 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 20 | 15 | NE |
| S. AFRICA | 15 | 15 | 12 | 10 | 10 | 10 | 12 | 12 | 15 | 15 | 15 | 15 | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | E |
| S. AMERICA | 15 | 15 | 12 | 12 | 10 | 10 | 10 | 12 | 12 | 15 | 15 | 15 | _15_ | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 20 | 20 | 15 | 15 | 15 | SE |
| ANTARCTICA | 15 | 15 | 15 | 15 | 15 | _20_ | _20_ | _20_ | _20_ | _20_ | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | S |
| NEW ZEALAND | 10 | 12 | 12 | 12 | 15 | 15 | 15 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | _20_ | 15 | 15 | 15 | 12 | 12 | 12 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 12 | 12 | 15 | 15 | 15 | 20 | 20 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 15 | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 12 | W |
| JAPAN | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 15 | NW |
| CST | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | |

### EASTERN USA

| EST | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | 6:00 | 5:00 | 4:00 | 3:00 | 2:00 | 1:00 | 12:00 | 11:00 | 10:00 | 9:00 | 8:00 | 7:00 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASIA FAR EAST | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 20 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | _20_ | _30_ | _30_ | 30 | 30 | 30 | 30 | 20 | 20 | N |
| EUROPE | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 20 | NE |
| S. AFRICA | 15 | 15 | 15 | 12 | 10 | 10 | 10 | 12 | 12 | 15 | 15 | 15 | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | E |
| CARIBBEAN S. AMERICA | 15 | 15 | 12 | 12 | 12 | 10 | 10 | 10 | 12 | 12 | 15 | _15_ | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 20 | 20 | 15 | 15 | 15 | 15* | SE |
| ANTARCTICA | 15 | 15 | 15 | 10 | 15 | _20_ | _20_ | _20_ | _20_ | _20_ | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 20 | 20 | 15 | 15 | 15 | S |
| NEW ZEALAND | 10 | 12 | 12 | 12 | 15 | 15 | 15 | 15 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | _20_ | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | 10 | SW |
| OCEANIA AUSTRALIA | 12 | 12 | 15 | 15 | 15 | 20 | 20 | 20 | 20 | _20_ | _20_ | _20_ | _20_ | _20_ | 20 | 20 | 15 | 15 | 15 | 12 | 12 | 10 | 10 | 10 | W |
| JAPAN | 20 | 20 | 20 | 20 | 20 | 20 | 20 | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | _30_ | 20 | 20 | 20 | 15 | 15 | 15 | 15 | 15 | 15 | NW |

The italicized numbers signify the bands to try during the transition and early morning hours, while the standard type provides MUF during "normal" hours.

*Look at next **higher** band for possible openings.

Twenty should stay open on long southern paths into the night, while 15 will drop out in the late afternoon. DX is 5000 to 7000 miles (8000-11,200 km) on these bands and one-long-hop transequatorial propagation is also possible as on 10 meters.

Thirty and 40 meters are both day and night bands. Intermediate distances (1000-1500 miles, 1500-2200 km) in any direction represent daytime DX. Nighttime DX on these bands may be expected to offer a greater distance than on 80 meters and, like 80, follow the darkness path across the sky. Reduced midday signal strengths and distances may occur on days of high solar flux values.

Eighty and 160 meters will exhibit short skip conditions during daylight hours and lengthen for DX at dusk. These bands follow the darkness path, opening to the east just before local sunset, swinging more to the south near midnight, and ending up in the Pacific areas shortly before dawn. The 160-meter band opens later and ends earlier.

**ham radio**

# ELMER's NOTEBOOK

**Tom McMullen, W1SL**

## antenna tuner

**In last month's Notebook** I discussed transmission lines and their construction and impedance. The May 1988 *ham radio* is the annual antenna issue, so next month's column will focus on that subject. In this issue, let's look at another part of a transmitting/receiving system — the "antenna tuner".

Most everyone calls the device used by Amateurs between their station and the antenna an "antenna tuner", even though this isn't really what it is. The proper term is *impedance-matching circuit*, but that just doesn't turn people on the way "antenna tuner" does. In earlier days, the circuitry used to get an antenna to "load" was an antenna tuner of sorts; the end of the antenna was brought right into the shack and tapped on the tuned circuit. Adjustments were made by changing the coupling link from the transmitter and moving the antenna tap on the coil, **fig.1**.

This system worked, and still does, but it has faults. For one, it brings a lot of rf right into the shack. This was okay in the days of vacuum tubes that were not too sensitive to the presence of rf, but stray rf certainly creates big problems with today's semiconductors, not to mention nearby TV and hi-fi sets.

Getting the antenna out of the shack and up in the air had two desirable results: it reduced the rf problem and improved radiation by being in the clear, away from nearby objects. This created the need for a transmission line to conduct power between the transmitter and the antenna, but did not eliminate the need for some type of matching device at the transmitter output. No two antennas are alike in installation, environment, construction,

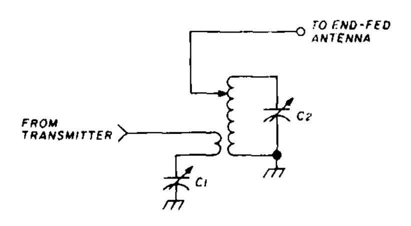



**fig. 1. Matching circuit for an end-fed wire antenna. The tap is moved along the coil until the transmitter is properly loaded.**

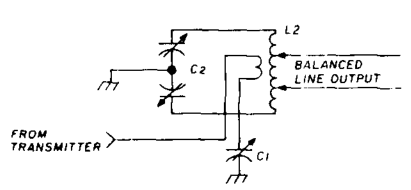



**fig. 2. A simple circuit for providing a match between 50- or 75-ohm coaxial cable and parallel-wire transmission line of any impedance.**

or impedance and method of feed, and what works well on one band is not necessarily the optimum choice for another. Operation over a wide portion of any band creates another problem. You can make the length of an antenna correct for one part of a band but it is not resonant in another part, so if you move your operating frequency very far you'll see the VSWR start to climb. Some rigs will put up with this, but many will not.

Enter the impedance-matching circuit, sometimes called a "Transmatch" or "antenna Coupler" or "antenna Tuner."

A basic circuit is shown in **fig. 2**. The simple tuned circuit has a link to couple energy from the transmitter to it, and taps on the coil for matching to twin-lead transmission line. This type is ideal when you have a center-fed dipole with a feedline of TV ribbon or open-wire "ladder line." The capacitor ($C_1$) in series with the link "tunes" it for maximum coupling of energy from the transmitter. $C_2$ and $L_2$ form a resonant tank at the operating frequency. The taps are simply moved equal distances from the center of the coil until the transmitter shows proper loading.

A "Transmatch" or "*Ultimate* Transmatch" is another all-purpose tuner. It one of the most useful, wide-range matching circuits in Amateur radio, and has several variations. The basic circuit is shown in **fig. 3**. The transmitter input is coupled to the circuit by $C_1$, and the combination of variable capacitance of $C_1$, inductance $L_1$, and the output capacitor $C_2$ provide matching for a load that can be anything from 50-ohm coaxial cable to open-wire line or a single-wire end-fed antenna (if you still want to bring rf back into the shack).

The inductance ($L_1$) for this kind of circuit is usually variable, consisting of

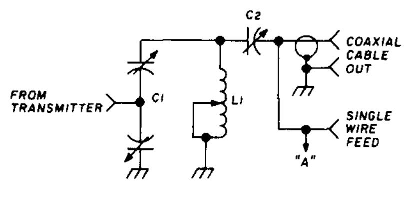



**fig. 3. A versatile Transmatch type of matching circuit. The variable capacitors and inductor allows it to perform over a wide range of frequencies and impedances. As shown here, the output will accept either coaxial cable or single-wire feed (as for an end-fed antenna).**

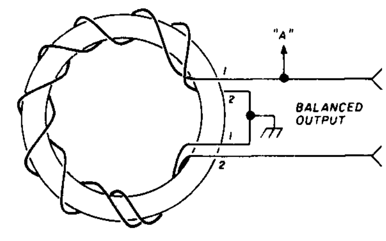



**fig. 4. A balun transformer is a useful addition to the Transmatch circuit. The point labeled "A" connects to "A" in *fig. 3*.**

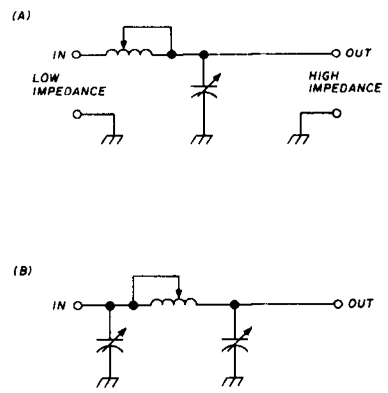



**fig. 5. The L network, at A, is useful for matching some types of antennas, particularly a vertical radiator where the circuit is placed at the base. The Pi circuit at B will match a very wide range of input and output impedances. It can accept low or high impedances at either the input or output.**

turns of wire on a ceramic cylinder that can be rotated by a knob on a panel. The tap is a roller that contacts the turns of the wire as the inductor is rotated providing a continuously variable inductance which (along with $C_2$) matches a wide range of impedances. A variation of this circuit uses a tapped inductor and a well-insulated switch to select the proper value, eliminating the hard-to-find roller inductor.

A balun transformer allowing connection to a balanced line is a useful addition to this Transmatch circuit; one is shown in **fig. 4**. It can be built into the same enclosure as the Transmatch, or as a separate unit and attached to the coaxial connector. If you build it into the Transmatch circuit enclosure, connect the points shown as "A" in **figs. 3** and **4**. The transformer is wound on a ferrite core.

Commercial Transmatches are available but they are not difficult to construct in the home workshop. Looking for the roller inductors and variable capacitors to build a Transmatch is a favorite pastime of Amateurs at hamfests and flea markets. It is a popular project.

There are other circuits that can be used to match impedances; two of the most common are the "L" network and the "Pi" network in **fig. 5**. The L network is useful for matching a low impedance to a high one. The lower impedance must always be connected to the inductance end of the circuit and the higher impedance must always be across the capacitor. This circuit works well as an "antenna tuner", placed at the base of a vertical antenna and adjusted to provide a match between the antenna and the feedline to the transmitter.

The Pi network covers the widest range of any common circuit, and was for years the mainstay of impedance-matching techniques. Many transmitters used this type of circuit at the output of the power amplifier, and it was said that they would "match anything". I can personally attest to one trial to see if this was true.

In Willimantic, Connecticut, three of us decided one evening to see if this circuit really would (as a popular saying of the time claimed) "load a piece of wet string". We soaked some heavy twine in a bucket of salt water and quickly connected it to the network, suspending the far end over the limb of a convenient tree. We made a contact on 20 meters, but the rf power kept drying out the string so we had to re-wet it while our operator was receiving. He then waited for our "ready" yell before transmitting. I don't think the guy at the other end of the contact ever believed us, even when he got the QSL card listing the antenna as "1/2-wave wet string"!

The Pi network is bi-directional; either end can be the high- or low-impedance port.

## receiver benefits from matching (circuit)

In addition to the impedance-matching, these circuits also reduce harmonics that might otherwise get to the antenna and be radiated. Also, when the selective circuit is placed between the antenna and the receiver, interference from strong stations outside the Amateur bands is reduced. Receivers, like transmitters, do perform better when their input impedance is properly matched.

It is important to remember that none of these circuits change your antenna impedance or reduce the VSWR on the transmission line feeding your antenna. If your dipole on 15 meters looks like 7-1/2 ohms at the feedpoint, absolutely nothing you do in your shack will change that. Likewise, if the VSWR on the transmission line is 15:1, it is going to stay there no matter what kind of "matcher" you use. The main function of a matching circuit in your shack is to present your transmitter with a proper load. Any VSWR problems on the feedline can be cured only by working on the antenna itself or by placing a matching circuit right at the antenna feedpoint. It's okay if the VSWR is moderate — systems with 3:1 or 4:1 on the line between the antenna and the Transmatch do their job just fine. At values higher than that, you are losing some power in the feedline and perhaps radiating some of it from the line rather than the antenna, so some antenna work is in order.

## operating practices

No one likes to hear stations tuning up in the middle of their QSO, but these circuits do require adjustment from time to time. Here are a few tips to make life easier for everyone:

- On most matchers, the variable capacitors and inductors have calibrated knobs, dials, or multiturn indicators. Make a calibration chart or marks on the panel listing the tuning positions for each of your favorite bands and operating frequencies. Then you will need to make only minor adjustments, or perhaps none at all, when you change frequency.
- Initial tuning and calibrating of the Transmatch should be done when a particular band is dead, using the lowest value that your power and SWR meters will accurately indicate. Your VSWR is not going to change if you tune up with 5 watts and then use 200 for QSOs.
- Do your initial tuning of the transmitter only into a dummy load, then switch to the matching network. From then on, make minor adjustments of the matching network to keep the transmitter happy; don't readjust the transmitter tuning. Some Transmatches have a built-in switch to select a dummy load, and a power/SWR meter to aid in tune-up. Both are worthwhile additions if you build your own.

## the other side of the coin

On the other hand, Transmatches (and all matching networks, for that matter) lose some of the power on the way through. Circuits constructed with quality components — heavy or silver-plated wire, and inductors and capacitors with steatite or ceramic insulation — have losses small enough to ignore. Poor insulation and small wire can increase losses significantly. Also, some circuits are built using toroidal transformers and if their core material is not meant for use at the frequency of operation, the losses will be large.

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# NEW products

## new pocket HTs from Kenwood

The new Kenwood TH-25 Series HT is compact with wideband frequency coverage, big LCD display, and 5 watts output option.

Operating features include: front panel DTMF pad, automatic power control, 14 memories, automatic offset selection, band and memory scan, automatic "power off" circuit, and CTCSS encode/decode option. Accessories supplied with the unit are: StubbyDuk, battery pack, wall charger, belt hook, wrist strap, and water resistant dust caps.

Contact Kenwood Amateur Radio dealers for details and information on accessories. The suggested retail price for the TH-25AT is $329.95; the TH-45AT is priced at $349.95.

## ALPHA linear amplifiers

Ehrhorn Technological Operations has introduced a new ALPHA line of linear amplifiers.

The ALPHA 86 features 1500 watts output power, PIN diode T/R switching for full QSK, and easy tune-up. It maintains full output in any mode with no key-down time limit and uses a pair of Eimac's 3CX800A7 tubes.

The ALPHA 87 needs no tune-up; factory pretuned bandpass circuits allow instant QSY to any hf band.

The ALPHA 88 is a fully automatic version of the ALPHA 86. A microprocessor is preprogrammed at the factory for all Amateur bands. The ALPHA 88 samples the input frequency and automatically tunes the tank circuits.

For more information contact Ehrhorn Technological Operations, Inc., P.O. Box 888, 451 Valley Road, Canon City, Colorado 81212.

**Circle #301 on Reader Service Card.**

## new Hamtronics catalog

Hamtronics, Inc. 1988 catalog has kits and wired units for Amateur radio, two-way shops, and scientific and industrial radio users. New product listings include: R901 fm receiver for 902-928 MHz, R137 weather satellite receiver for the 137-MHz band, an AP3 repeater autopatch module, 70-watt hi-band and UHF repeater power amplifiers, and a complete system for 9600 baud packet radio linking.

To order send $1 ($2 for overseas) to Hamtronics, Inc., 65-F Moul Road, Hilton, New York 14468-9535.

## new antennas, solar power supply

The QRV 160-10 is a low-visibility, all-band hf antenna originally created for rapid emergency installation. Thanks to special kinkproof wire, installation can easily be completed by a single individual. Insulated and completely weather-sealed, the QRV 160-10 may be connected directly to a transceiver or a transmatch by means of its PL 259 connector. The feedline may be extended as necessary with 50-ohm coaxial line. Based on the popular G5RV design, the QRV 160-10 measures 102 feet from end to end, and can be installed in dipole, V, sloper, or folded configurations. Unique adjustable insulators facilitate bending to fit available space. An extensive technical manual explains how to obtain desired results from difficult installation sites, including spans as short as 26 feet. The QRV 160-10 is rated for full legal power. It comes ready to use, and is priced at $49.95, including U.S.delivery.

AntennasWest has also introduced its QRV-Solar 23 Solar Power Supply, designed to provide independent power for remote repeaters, portable or RV-based stations, and hamshack installations. The heart of the system is an easily installed, unbreakable and bullet-tested solar panel with unique linear current boosting circuitry. Rated at 23 watts, the QRV-Solar 23 delivers 1.65 amperes at 14 volts and increased current at lower voltages.

The QRV-Solar 23 is available for immediate delivery from AntennasWest at $289.95 postpaid. An optional kit for mounting on vertical masts is available at $34.95.

For further information on these new products, contact AnntennasWest, 1971 North Oak Lane 1300, Provo, Utah 84604-2138.

**Circle #302 on Reader Service Card.**

## HL-250U linear amplifier

The HL-250U is a high-power linear amplifier for Amateur UHF band all mode operation. It provides a maximum output power of 250 watts when driven by any 10 or 25 watt radio through the automatic drive level select circuit. The HL-250U is solid-state, requires no tuning, has forced air cooling with stable output and high voltage safety measures provided. The built-in low-noise GaAsFET receive pre-amp enables comfortable UHF DX QSOs.

The suggested retail price of the HL-250U is $824.95. For more information contact ENCOMM, Inc., 1506 Capital Avenue, Plano, Texas 75074.

**Circle #303 on Reader Service Card.**

## antenna design and construction aid

A new approach to antenna design and construction is offered by Epsilon Company. It is the only antenna design program featuring a sinusoidal projection of the antenna's radiation pattern. This approach shows the signal intensity at all angles, horizontal and vertical of the antenna simultaneously, referenced to isotropic. It's like sitting in a planetarium. At the center of the floor is your antenna which is the only source of light. The dome or sky is illuminated according to signal intensity at each point. Long Wire Pro's sinusoidal projection is a sophisticated flat projection of the sky, color coded according to signal intensity. You can explore the projection with a mouse or cursor keys and read in a numeric window the gain at a particular azimuth and elevation.

Long Wire Pro lets you select wire lengths, for center-fed and end-fed long wires, Vee's, and rhombics. Next choose the height above ground, the kind of ground, such as moist, dry, average, etc. Then enter the slant of the antenna over ground.

The projection is then drawn in the center of the screen. Above this is a window showing a table of the antenna's parameters you've entered along with the maximum gain, azimuth, and elevation referenced to isotropic, the overall dimensions, and in the case of terminated antennas, the recommended termination resistor. All this can be printed on a dot matrix printer.

One can simulate many antennas in less than ideal real conditions. Odd wire lengths, antenna slants, and low ground conductivity are all conditions that cause radiation pattern to change from published patterns.

Long Wire Pro runs on IBM-PC/XT/AT's and compatibles with 256K or more, DOS 2.0 or higher, and color is required. It makes use of 8087/80287 math co-processor if present, and also a mouse if present. The disk contains two files, one will run on 160K RAM, and the other on 450K of RAM. The small version is intended to run on 256K computers and has 3 degree resolution. The large file's program has 1 degree resolution. In all other respects they are the same.

Epsilon is selling Long Wire Pro for $35.00, and it can be ordered from Epsilon Co., P.O. Box 715, Trumbull, Connecticut 06611.

**Circle #306 on Reader Service Card.**

# here is the next generation Repeater
**2 meters - 220 - 440**

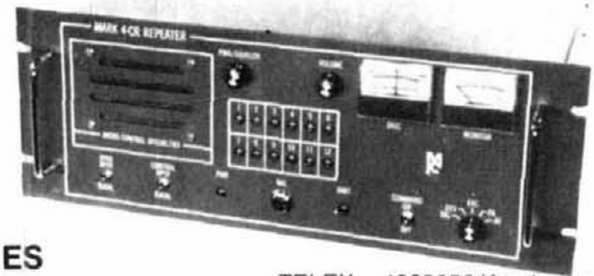
## MARK 4CR

The **only** repeaters and controllers
with REAL SPEECH!

No other repeaters or controllers match Mark 4 in capability and features. That's why Mark 4 is the performance leader at amateur and commercial repeater sites around the world. Only Mark 4 gives you Message Master™ real speech • voice *readout* of *received* signal strength, deviation, and frequency error • 4-channel receiver voting • clock time announcements and *function control* • 7-helical filter receiver • extensive phone patch functions. Unlike others, Mark 4 even includes power supply and a handsome cabinet.

Call or write for specifications on the repeater, controller, and receiver winners.

Create messages just by talking. Speak any phrases or *words in* any languages or dialect and *your own voice* is stored instantly in solid-state memory. Perfect for emergency warnings, club news bulletins, and DX alerts. Create unique ID and tail messages, and the ultimate in a real speech user mailbox — only with a Mark 4.

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## THE RF CONNECTION

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| 321-11064-3 | BNC 2 PST 28 volt coaxial relay, Amphenol<br>Insertion loss: 0 to 0.75GHz, 0.10dB<br>Power rating: 0 to 0.5GHz, 100 watts CW, 2 kw peak<br>Isolation: 0.1 GHz/45db, 0.2 GHz/40db, 0.4 GHz/35db | $25 used tested |
| 83-822 | PL 259 Teflon, Amphenol | 1.50 |
| PL-259/ST | UHF Male Silver Teflon, USA | 1.50 |
| UG-21D/U | N Male RG-8, 213, 214, Amphenol | 2.95 |
| UG-21B/U | N Male RG-8, 213, 214, Kings | 4.00 |
| 9913/PIN | N Male Pin for 9913, 9086, 8214 fits UG-21D/U & UG-21B/U N's | 1.50 |
| UG-21D/9913 | N Male for RG-8 with 9913 Pin | 3.95 |
| UG-21B/9913 | N Male for RG-8 with 9913 Pin | 4.75 |
| UG-146/U | N Male to SO-239, Teflon USA | 5.00 |
| UG-83/U | Female to SO-239, Teflon USA | 5.00 |

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**Wideband Preamp 10-1000 Mhz**

Dual GasFet low noise preamplifier for HF, UHF or VHF systems. Just perfect for the R-7000. Excellent for Spec Analyzers, Scanners, etc. Gain 20 Db +/- 1 DB, -3 Db at 2 & 1100 Mhz. 1 Db compression of >10 Dbm. Intercept points >45 Dbm. New shipped price of only $124.95. Pa. residents please add 6% state tax.

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## new AMECO preamplifier

AMECO has introduced the model PT-3 Preamplifier, successor to the model PT-2. The PT-3 is a continuously tunable preamplifier that covers 1.8 through 54 MHz packaged in a cabinet with a dark-colored panel. Options are available for second receiver and separate receiving antenna capabilities.

The retail price for the PT-3 Preamplifier is $109.95; the price for the P-12T Adapter is $8.95.

For details contact AMECO, 220 E. Jericho Turnpike, Mineola, New York 11501.

**Circle #305 on Reader Service Card.**

## advanced hf station transceiver

ICOM's new IC-781 hf base station operates on all modes and bands from 10 to 160 meters. A band spectrum scope displays signals in a 50/100/200 kHz range of your operating frequency on a multifunction 5-inch CRT screen.

The IC-781 also features:

- dual band watch
- twin passband tuning
- 99 tunable memories
- wide and narrow filters
- direct keyboard entry
- 150 watts output
- built-in power supply
- dual noise blanker
- five multifunction timers
- two internal clocks

The IC-781 comes standard with: built-in high speed automatic antenna tuner, iambic keyer, semiautomatic or full QSK CW break-in to 60 wpm, audio peaking filter, rf speech processor, multiscanning, 105-dB dynamic range receiver that continuously tunes 100 kHz to 30 MHz, plus exceptional frequency control.

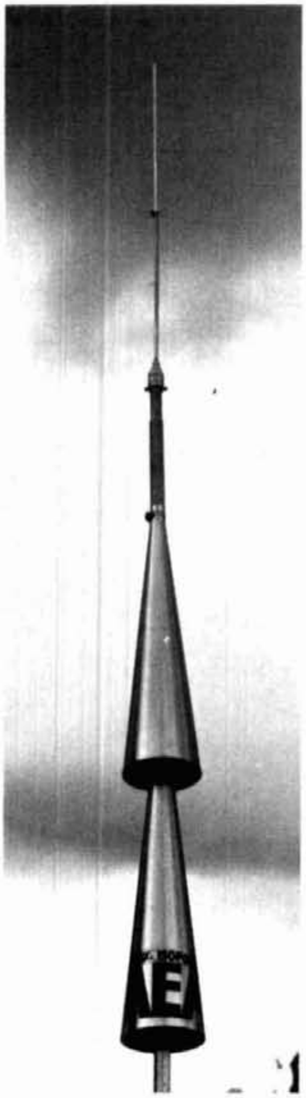
For additional information contact ICOM America, Inc., 2380 116 Avenue, N.E., Bellevue, Washington 98009.

**Circle #304 on Reader Service Card.**

# Put More Punch in Your Packet

Outstanding mechanical design makes the IsoPole the only logical choice for a VHF base station, especially for Packet operation. All Isopole antennas yield the **maximum gain attainable** for their respective lengths and a maximum signal on the horizon. Exceptional decoupling from the feed line results in simple tuning and a significant reduction in TVI potential. The IsoPole antennas are all impedance matched in the factory so that no field tuning is required. The IsoPoles have the broadest frequency coverage of any comparable VHF base station antenna. This means no loss of power output from one end of the band to the other, when used with SWR protected solid state tranceivers. **Typical SWR is 1.4 to 1 or better across the entire band.**

A standard 50 Ohm SO-239 connector is recessed within the base sleeve (fully weather protected). With the IsoPole you will not experience aggravating deviation in SWR with changes in weather. The impedance matching network is weather sealed and designed for maximum legal power. The aerodynamic cones are the only appreciable wind load and are attached directly to the support (a standard TV mast which is not supplied).



**High Performance Hand-Held Antenna — The Hot Rod**

The Hot Rod antenna can be expected to make the same improvement to hand-held communications that the IsoPole antennas have made to base station operation. **Achieve 1 or 2 db gain** over ANY 5/8 wave two meter telescopic antenna. The factory tuned HR-1 is 20% shorter, lighter and places far less stress on your hand-held connector and case. It will easily handle over 25 watts of power, making it an excellent emergency base or mobile antenna. In the collapsed position, the Hot Rod antenna will perform like a helical quarter wave. Three Hot Rods are available; HR-1 1/2 wave 2M Ant., HR-2 for 220 Mhz, and HR-4 for 440 Mhz. Amateur Net Price on all Hot Rods is $19.95.

For either base station or hand-held operation AEA has the perfect VHF/UHF antenna. Put more punch in your Packet station with an AEA IsoPole or Hot Rod antenna. To order your new antenna contact your favorite Amateur Radio Distributor. For more information contact Advanced Electronic Applications, P.O. Box C-2160, Lynnwood, WA 98036, or call 206-775-7373.

**IsoPole Specifications**

| Model | 144 | 220 | 440 |
|---|---|---|---|
| Freq. Coverage (Mhz) | 135-160 | 210-230 | 415-465 |
| 2.1 VSWR bandwidth | >12Mhz @ 146Mhz | >15Mhz @ 220Mhz | >22Mhz @ 435Mhz |
| Power Rating | 1 kw | 1 kw | 1 kw |
| Gain** | 3 dbd | 3 dbd | 3 dbd |
| Radiating Element Length | 125.5" (3.2m) | 79.25" (2m) | 46" (1.2m) |
| Amateur Net Price | $49.95 | $49.95 | $69.95 |

**dbd — db gain over a dipole in free space

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Prices and Specifications subject to change without notice or obligation.

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# flea market

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WANTED ATLAS 350-XL. N5NM, Box 2169, Santa Fe, NM 87504 (505) 988-2305.

**CALL SIGN BADGES:** Custom license plate holders. Personal, distinctive. Club discounts. SASE. WB3GND, Box 750, Clinton, MD 20735. (301) 248-7302.

**RADIO BROADCAST EQUIPMENT.** Cash Paid. Especially interested in newer studio and transmitting equipment and acessories. Jon, WB4MMV, 139 Woodlake Drive, Charlottesville, VA 22901. (804) 973-8697.

**MACINTOSH SATELLITE** and Propagation Software. MacTrak ™displays graphic maps (rectangular, polar, great circle), views from space, schedules, windows. Also tracks Sun and Moon. Compatible with KLM/MIRAGE rotor interface. Shows gray line, sunrise/sunset, bearing/distance, MUF vs time, areas of world "open". SASE for info or $49.95 from F. Stegemeyer, PO Box 1590, Port Orchard, WA 98366.

**SB220 OWNERS:** Add 160 meters, QSK, +8 additional enhancements. 40 page step by step manual includes parts sources, and 3-500z tech manual. SASE for details. $10 plus $1 postage. WA2SQQ, 69 Memorial Place, Elmwood Park, NJ 07407.

**HALLICRAFTERS** 12 band receiver Model 1200, Inspection No. 77040955, portable deluxe. Schematic desired. Elbridge MacKenzie, 186 Graceland Avenue, Anderson, IN 46012.

**WANT DRAKE VFO RV-75.** Meyer Minchen, AG5G, 1753 North Blvd, Houston, TX 77098 (713) 622-6161 (24 hours).
WANTED TEN-TEC ARGONAUT. N5NM, Box 2169, Santa Fe, NM 87504. (505) 988-2305.

**ANALOG AND RF CONSULTING** for the San Francisco Bay area. Commercial and military circuits and systems. James Long, Ph.D., N6YB (408) 733-8329.

**COMMODORE CUSTOM CHIPS FOR C64/128** Computer/peripherals at low prices. 24 hour delivery. #6510- $9.95, #6526- $9.95, #6567- $14.75, #6581- $12.85, PLA- $12.50, 901 ROMS at $10.95 each and many others, including Amiga..."The COMMODORE DIAGNOSTICIAN". A complete diagnostic reference chart for fixing Commodore computers, etc. An absolute must for those who want to fix their own computers and save money and downtime. $6.95 plus $1.00 postage... COMMODORE REPAIR. We are the largest/oldest Authorized Service Center in the country. (eg. C64- $39.95). Fast turnaround. Heavy duty Power Supply for C64- $27.95 plus UPS. Send for complete chips/parts catalog...VISA/MC...Kasara, Inc, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-642-7634, 800-248-2983 (outside NY) or 914-356-3131.

**WANTED:** Klystron tubes especially 2911; Magnatrons; also 304TL, 6012, 810 and 5CX1500A. All types of sockets for transmitting tubes. Harold Bramstedt, 6104 Egg Lk Rd, Hugo, MN 55038. (612) 429-9397.

**SUPERFAST MORSE CODE SUPEREASY.** Subliminal cassette. $10. Learn Morse Code in 1 hour. Amazing new supereasy technique. $10. Both $17. Moneyback guarantee. Free catalog: SASE. Bahr, 2549-H2 Temple, Palmbay, FL 32905.

**HF PARTS.** GaAs fets, mimics, chip caps, trimmer caps, and other builder parts. MGF 1402 @$14.00. MFG 1302 @$10.00. .8-10pf Trimtronics trimmer @$3.75. Porcelain chip caps @$1.75. Orders add $1.00 p + h. SASE for complete list. MICROWAVE COMPONENTS, 11216 Cape Cod, Taylor, MI 48180.

**WA9GFR COMMUNICATIONS SOFTWARE.** $15.00 disk contains HF/VHF/UHF/L-Band propagation programs to predict range in miles based on transmitter power, receiver sensitivity, and antenna height & gain. A "must" for designing repeater installations. Also includes Smith Chart impedance matching programs. Commodore 64 or IBM. Lynn Gerig, RR1, Monroeville, IN 46773.

**BM-PC RTTY/CW.** New CompRtty II is the complete RTTY/CW program for IBM-PC's and compatibles. Now with larger buffers, better support for packet units, pictures, much more. Virtually any speed ASCII, BAUDOT, CW. Text entry via built-in screen editor! Adjustable split screen display. Instant mode/speed change. Hardcopy, diskcopy, break-in buffer, select calling, text file transfer, customizable full screen logging, 24 programmable 1000 character messages. Ideal for MARS and traffic handling. Requires 256k PC or AT compatible, serial port, RS-232C TU. $65. Send call letters (including MARS) with order. David A. Rice, KC2HO, 25 Village View Bluff, Ballston Lake, NY 12019.

**TELEVISION SETS** made before 1946, early TV parts, literature wanted for substantial cash. Especially interested in "mirror in the lid" and spinning disc tv's. Finder's fee paid for leads. Arnold Chase, 9 Rushleigh Road, West Hartford, Conn. 06117. (203) 521-5280.

**ENGINEERS** request free catalog of Electronics Software. Circuit analysis, filter design, graphics, etc. BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501 (714) 781-0252.

**JENNINGS UCS-300-7.5 KV** variable vacuum capacitor $135, RJ1A/HC-1 vacuum relay $75, RJ2C $140. Cardwell 2100pF-3 KV variable capacitor $45. Eimac 3CX1200A7 $375, 4CX3,000A $675, 4CX5,000A $950, SK-2210/SK 2216 $85. Centralab 858-1000pF $5 ea. (All new). A. Emerald, 8956 Swallow, Ftn. Vly. CA 92708 (714) 962-5940.

**PACKET PACKET.** Homebrew a $25 interface and operate packet radio with Commodore 64 or 128. Information packet and schematics $6. Free program disc. Nona Norman, N8CKS, 41991 Emerson Court, Elyria, OH 44035.

**TEKTRONIX 547** Oscilloscope, 50 MHz BP $135, Tek-1A1 $60, Tek-1A4 $120, Tek-1L30 Spectrum Analyzer, 0.9-10.5 GHz $350, Hewlett-Packard 606A Signal Generator, 0.05-65 MHz, $100k, HP-8708A Synchronizer $150, HP-3300A Function Generator $95, HP-686C Sweep Generator, 8-12 GHz $95, HP-9865A Cassette Memory $95. Lambda LB-701-FMOV Variable Regulated Power Supply, 300 amps, new $295.

**MICROWAVE MODULES AND PARTS.** Oscillators (50 to 4000 MHz) specify frequency $50.00. Double balanced mixers $10.00. Coaxial relays DC to 12.4 GHz and up to 750 watts CW 1P3T $45.00, 1P6T $60.00. Also test equipment H-P and Tektronix. Much more. Send SASE. Don Sands, WA5OYG, 1619 Fair Oaks Lane, Richmond, Texas 77469.

**SELL:** AEA PK-64A/HFM packet $225, Icom IC-271A 2M Xcvr $589, Hallicrafters SX-115 RX $300, Spectrum Communications 2M Repeater TX/RX circuit boards $65 each and others inquire. Floyd, K5LA (915-751-6204) 5637 Prince Edward Avenue, El Paso, TX 79924.

**WANTED:** Beginning Collector - Lover and user of old bugs and keys looking for early model items. Also interested in foreign and unusual bugs and any literature on the old bugs and keys. Please state price and condition or call collect. Smiley White, WB4EDB, POB 5150, Fredericksburg, VA 22403. (703) 373-0996.

**OLD HEATH RADIO GEAR?** Have it reconditioned, aligned, calibrated. SASE for quote. RTO Electronics, 4166 Maple Street, Berrien Springs, MI 49103.

**ICOM 730 HF TRANSCEIVER** $400.00, power supply I used with ICOM $50.00. ICOM 4AT, 4 battery packs, no charger. Has SS-32M CTCSS encoder set for 100 Hz and 114.8 Hz $150.00, 1 CoColl system 64K, 35 track SS drive with controller, DMP-100 Dot Matrix printer, needs new ribbon, with some programs $200.00. I will pay shipping on all above. 2 met. Duplexer, Sinclair QZ22OE, 500 kHz min spacing. $300.00. Unsure how to ship this item. It's like new. James Perkins, PO Box 8, Schriever, LA 70395. Day phone (504) 446-8841, evenings after 4 PM CST (504) 575-2542.

**RTTY JOURNAL**—Now in our 36th year. Read about RTTY, AMTOR, PACKET, MSO'S, RTTY CONTESTING, RTTY DX and much more. Year's subscription to RTTY JOURNAL $10.00, foreign slightly higher. Order from: RTTY JOURNAL, 9085 La Casita Ave., Fountain Valley, CA 92708.

**IMRA** International Mission Radio Association helps missionaries. Equipment loaned. Weekday net, 14.280 MHz, 1-3 PM Eastern. Nine hundred Amateurs in 40 countries. Rev. Thomas Sable, S.J., University of Scranton, Scranton, PA 18510.

**MARCO:** Medical Amateur Radio Council, Ltd, operates daily and Sunday nets. Medically oriented Amateurs (physicians, dentists, veterinarians, nurses, physiotherapists, lab technicians, etc) invited to join. Presently over 550 members. For information write MARCO, Box 73's, Acme, PA 15610.

**RUBBER STAMPS:** 3 lines $5.00 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

**ELECTRON TUBES:** Receiving, transmitting, microwave... all types available. Large stock. Next day delivery, most cases. DAILY ELECTRONICS, PO Box 5029, Compton, CA 90224. (213) 774-1255.

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**PACKET RADIO AMATEUR.** Announcing a new heavy duty C-64 Commodore replacement power supply especially for the Packet Radio Amateur. The new higher amperage output will now allow for 24 hour continuous "Packet" operation without voltage change or failure which the existing unit can succomb to. This P.S. is an exact physical replacement and will not run hot. $27.95 + pp...VISA/MC. Kasara Inc, 36 Murray Hill Drive, Spring Valley, NY 10977. 1-800-248-2983 (Nationwide) or 914-356-3131.

**RECONDITIONED TEST EQUIPMENT** $1.25 for catalog. Walter, 2697 Nickel, San Pablo, CA 94806.

## COMING EVENTS

### Activities — "Places to go . . ."

**SPECIAL REQUEST TO ALL AMATEUR RADIO PUBLICITY COORDINATORS:** PLEASE INDICATE IN YOUR ANNOUNCEMENTS WHETHER OR NOT YOUR HAMFEST LOCATION, CLASSES, EXAMS, MEETINGS, FLEA MARKETS, ETC, ARE WHEELCHAIR ACCESSIBLE. THIS INFORMATION WOULD BE GREATLY APPRECIATED BY OUR BROTHER/SISTER HAMS WITH LIMITED PHYSICAL ABILITY.

**NEW JERSEY:** April 9. Ham Radio Flea Market sponsored by the Chestnut Ridge Radio Club, Education Building, Saddle River Reformed Church, East Saddle River Road and Weiss Road, Upper Saddle River. Admission $1.00. Tables $10.00 first, $5.00 each additional. Tailgating $5.00. Contact Jack Meagher, W2EHD (201) 768-8360.

**WASHINGTON:** April 9. 11th annual Inland Empire Hamfest, Red Cross Bingo Hall, West 708 Boone, Spokane. 8 AM to 5 PM. Admission $2.00. License exams, displays, forums, Packet Radio, MARS, Amateur satellites and more.

**ONTARIO:** April 9. The 7th annual Durham Region Amateur Radio and Computer Flea Market, Pickering High School, Church Street, Pickering Village, Ajax. 9 AM to 2 PM. Admission $3.00. Doors open 7:30 AM for vendors. Tables $7.00 prior to March 15, $8.00 thereafter. For information Ron Brown, VVE3WZ (416) 839-3711; Ray Koson, VE3NBE (416) 839-9208; Peter Schuyffel, VE3JPP (416) 282-3983.

**TENNESSEE:** April 9. The Clarksville Amateur Transmitting Society's annual Swapfest, National Guard Armory, Hwy 41A, Clarksville. 8 AM to 4 PM. Admission $2.0. Free parking. Refreshments available. Talk in on 145.805 or 147.39. For more information C.A.T.S. c/o WD4DBJ, Rt 1, Box 162A, Indian Mound, TN 37079.

**ILLINOIS:** April 17. The Moultrie Amateur Radio Klub (MARK) Hamfest, Moultrie County 4-H Fairgrounds, Cadwell Rd, 5 miles east of Sullivan. 8 AM to 3 PM. Indoor/outdoor flea market. No charge to vendors. Saturday setup. Tickets $2.00/advance or 3/$5.00. Amateur license exams by preregistration only. Talk in on .055/.655 and 52. For more information write MARK, PO Box 79, Sullivan, IL 61951 or call Vernon E. Jack, K9SWY, 217-728-7596.

**TENNESSEE:** April 17. The Maury Amateur Radio Club will sponsor its 2nd annual Indoor Hamfest, Maury County Park, Baker Building, Columbia. 8 AM to 4 PM. Admission $2.00. Children 12 and under free accompanied by adult. 8' flea market tables $8.00 each. Food and drink available. Talk in on 147.72/.12. To reserve tables or for more information George Russell, WB4JCR, PO Box 832, Columbia, TN 38402 (615) 388-0577.

**MASSACHUSETTS:** April 17. Tailgate Electronic Computer & Amateur Radio Flea Market. Sponsored by the MIT VHF Repeater Association and MIT Electronic Research Society. 9 AM to 4 PM. Albany and Main Streets, Cambridge. Admission $1.50. Free off-street parking for 1000 buyers. 200 tailgate spaces. $6/space at gate; $5 in advance includes one admission. Setup 7 AM. For information or space reservations call (617) 253-3776. Mail advance reservations before April 5 to W1XM c/o Mike Strange, 229 Commonwealth Avenue, Boston, MA 0216. Talk in on 146.52 and 449.725/44.725.

**CONNECTICUT:** April 17. The Southington Amateur Radio Association's 5th annual Flea Market, Southington National Guard Armory, 590 Woodruff Street, Southington. 9 AM to 1 PM. 8 AM for Dealers. Admission $2.00. Tables $8.00/advance; $10/door. Admits two. License exams all classes. Talk in on 146.28/88 and 145.600 simplex. For information contact Chet, KA1ILH, 628-9346, 5 to 9 PM.

**NEW MEXICO:** April 23 and 24. 24th annual Amateur Radio Extravaganza and Bean Feed. Dona Ana Fairgrounds West of Las Cruces. Sponsored by the Mesilla Valley Radio Club. Admission $5.00 both days. Kids under 12 free. Tables $6.00. Tailgates Free. VEC exams both days. RV parking available $5/night. Famous Sunday Bean Feed - tickets available at gate. Talk in on 146.04/146.64 and 146.16/146.76. For information Karl Hess, WF5A, 712 Stagecoach Drive, Las Cruces, NM 88001. (505) 646-5132 days or (505) 522-1172 evenings.

**MASSACHUSETTS:** April 24. The Montachusett ARA will hold a Flea Market at the George Wallace Civic Center, Fitchburg. 10 AM to 3 PM. Vendors setup 8:30 AM. Admission $2. Tables $10. Talk in on 144.85/145.45 and 146.52. For table reservations contact James Beauregard, KB1AY, 7 Mountain Avenue, Fitchburg, MA 01420.

**OHIO:** April 29. The 19th Annual B*A*S*H will be held on Friday night of the Hamvention at the Conference Center (Madison Room) of the HARA ARENA AND CONFERENCE CENTER, (the same location as the Hamvention), starting at 7:00 PM. There is no admission charge, and free continuous entertainment. Hot dinner, sandwichs, snacks and beverages are available. Two exciting top awards, and many others. Stay right at HARA when the Hamvention closes on Friday evening and meet your friends and join us for an evening of fun and entertainment. Sponsored by the Miami Valley F.M. Association, PO Box 263, Dayton, Ohio 45401.

**OHIO:** April 29. The Dayton-Cioncinnati chapter of the Quarter Century Wirless Association announces the annual QCWA banquet Friday evening at Neil's Heritage House. COD bar 6:30 PM; banquet 7:30 PM EST. Tickets $13.00 each. Bob Dingle, KA4LAU, 657 Delll Ridge Drive, Dayton, Ohio 45429 (513) 299-7114. Come join the fun.

**OHIO: DAYTON HAMVENTION WEEKEND.** April 29. The Third Annual DX Dinner hosted by the Southwest Ohio DX Association, Stouffers Dayton Plaza Hotel. Banquet $20.00 per person payable in advance to S.W.O.D.X.A. Send check or MO with SASE to Jay Slough, K4ZLE, 8183 Woodward Drive, West Chester, OH 45069.

**SOUTH CAROLINA:** April 30 and May 1. The 49th annual Greenville Hamfest sponsored by the Blue Ridge Amateur Radio Society, American Legion Fairgrounds, Greenville. License exams, indoor/outdoor flea market, food, concessions, free parking, camping and more. April- 30 8 AM to 5 PM; May 1- 8 AM to 3 PM. Admission $4.00 advance; $5.00 at the gate. For tickets and information SASE to BRARS, PO Box 6751, Greenville, SC 29606.

**NEW YORK:** May 1. The Suffolk County Radio Club Indoor/Outdoor Electronic Flea Market, Republic Lodge No. 1987, 585 Broadhollow Road, Melville, LI. 8 AM to 2 PM. Admission $3.00. Non-ham spouse and kids free. Indoor tables $10.00 each. Outdoor space $7.00. Includes one admission. Talk in on 144.61/145.21 and 146.52 simplex. For information Bill Sullivan, N2ETG (516) 689-9871 evenings.

**NEW YORK:** May 7. The 29th annual Southern Tier Hamfest, Treadway Ihn, Rt 17, Owego. Admission $4.00. Under 14 free. Dinner and gate ticket combined $15 in advance. VEC exams. League forum, displays, flea market. For more information or tickets SASE to STARC, PO Box 7082, Endicott, NY 13760.

**MINNESOTA:** May 7. Swapfest '88, sponsored by the Arrowhead Radio Amateur Club, First United Methodist Church, 230 East Skyline Parkway, Duluth. 10 AM to 3 PM. Admission $4.00. 4' tables $5.00. Talk in on 146.34/.94. For information contact Ron Carlson, K0BR, 5128 Wyoming Street, Duluth, MN 55804 (218) 525-6860.

**WISCONSIN:** May 7. The Ozaukee Radio Club is sponsoring its 10th annual Cedarburg Swapfest, Circle B Recreation Center, Highway 60 and County I, Cedarburg, 2 miles north of Milwaukee. 8 AM to 1 PM. Admission $2.00/advance, $3.00/door. 4' tables $3.00. Food and refreshments available. Sellers setup 7 AM. For tickets, maps or more information send business SASE to 1988 ORC Swapfest, 101 E. Clay St, Saukville, WI 53080 or call (414) 284-3271.

**ILLINOIS:** Kankakee. May 15. The annual Kankakee Hamfest, sponsored by the Kankakee Area Radio Society will be held at the Kankakee County Fairgrounds from 8 AM to 3 PM. Free flea market tables (limited) and many exhibitors. ARRL Booth. Free parking. Food and drinks available. Admission $2.50 advance, $3.00 at the door. Setup May 14 6 PM to 8 PM and May 15 6 AM to 8 AM. Talk in on 146.34/94. More information from KARS c/o Frank DalCanton, KA9PWW, RR 1, Box 361, Chebanse, Illinois 60922. Tel 815-932-6703 after 5 PM CST or 815-937-2452 before 5 PM CST.

**NEW JERSEY:** May 22. The Bergen County ARA is sponsoring its Spring Hamfest, Bergen Community College, 400 Paramus Road, Paramus. Rain or shine. 8 AM to 4 PM. Sellers $5.00 per tailgate space. Buyers free admission. License exams 8-11 AM. Testing information ONLY Pete Adely, K2MHP (201) 796-6622. For GENERAL information Jim Joyce, K2ZO, 286 Ridgewood Blvd, Westwood, NJ 07675. (210) 664-6725. Talk in on 146.19/79 and 52 direct.

## OPERATING EVENTS

### "Things to do . . ."

**APRIL 23:** The Great River ARC of Dubuque, Iowa will operate N9FVN from 1500Z to 2100Z at the site of the annual Boy Scouts of America U.S. Grant Pilgrimage in Galena, Illinois. Lower 20 KC of General Bands. Scouts will be able to send messages to relatives. For QSL card SASE to N9FVN, RR 1, Shullsburg, WI 53586.

**APRIL 23: INTERNATIONAL MARCONI DAY.** The Cornish Radio Amateur Club, Cornwall, England, and five other stations worldwide representing early Marconi station locations, will celebrate the birthday of Guglielmo Marconi on April 23, from 0000Z to 2400Z. Participating stations GB4IMD, VO1IMD, VE1IMD, EI2IMD, IY4FGM and K1VV/IMD Operation will be on General Class bands. For a certificate for working 5 of the 6 stations send 3 IRC's to the Cornish Radio Amateur Club, PO Box 100, Truro, Cornwall, England.

**MAY 7: BOY SCOUTS** of the DuPage Area Council will operate the Wheaton, Illinois, Community Radio Amateur Club station, W9CCU, from the DuPage County fairgrounds, 0400 to 0900 with WCRA youth as control operators. This Special Event station is intended to encourage Radio as a hobby for local youth. For certificate SASE to WCRA, PO Box QSL, Wheaton, IL 60189. Att: Scoutarama.

**THE FOUNDATION FOR AMATEUR RADIO, INC** plans to award twenty-eight scholarships for academic year 1988-89 to assist licensed Radio Amateurs who plan to pursue a full-time course of study beyond high school and are enrolled or have been accepted by an accredited university, college or technical school. For further information write FAR Scholarships, 6903 Rhode Island avenue, College Park, MD 20740 prior to May 31, 1988.

**HAM EXAMS:** The MIT UHF Repeater Association and the MIT Radio Society offer monthly Ham Exams. All classes Novice to Extra. Wednesday APRIL 20, 7 PM, MIT Room 1-150, 77 Mass Ave, Cambridge, MA. Reservations requested 2 days in advance. Contact Ron Hoffmann at (617) 646-1641. Exam fee $4.50. Bring a copy of your current license (if any), two forms of picture ID, and a completed form 610 available from the FCC in Quincy, MA (617) 770-4023.

# ADVERTISER'S INDEX AND READER SERVICE NUMBERS

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IC-761 NEWEST HF SUPER RIG
• 160-10M/General Coverage Receiver
• Built-in Power Supply and Automatic Antenna Tuner
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• QSK to 60 WPM
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• 140-149.995 MHz/ 440-450 MHz
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The excellent sensitivity of the 1200H makes it ideal for use with the telescoping RF pick-up antenna; accurately and easily measure transmit frequencies from handheld, fixed, or mobile radios such as: Police, firefighters, Ham, taxi, car telephone, aircraft, marine, etc. May be used for counter surveillance, locating hidden "bug" transmitters. Use with grid dip oscillator when designing and tuning antennas. May be used with a probe for measuring clock frequencies in computers, various digital circuitry or oscillators. Can be built into transmitters, signal generators and other devices to accurately monitor frequency.

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